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ABSTRACT

A study was prepared for the Department of Health, Education, and Welfare (DHEW) on the role DHEW could play in the implementation of instructional television. This volume of the study provides a detailed description of alternative delivery systems. It analyzes the different technical capabilities and component costs of a variety of distribution system configurations including cable television, pay television, closed-circuit television, video disc, video tape, UHF broadcasts, microwave systems, satellite systems, and computer-assisted instruction systems. A basis for cost comparison is then described. The report notes that while costs for procurement and distribution of program materials or services may be computed, means of obtaining revenue to support the distribution process often vary considerably. Moreover, those means of support are not fixed; one delivery system may depend on a combination of resources, whereas another system of the same type may be financed by a single method. Finally, the report notes that though the technology described exists, much of it has not gone beyond the demonstration stage. As a result, the most practical cash flow procedures have yet to be determined. (DC)

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EVALUATION OF THE MARKET FOR INSTRUCTIONAL TELEVISION AND THE EFFECTS OF CHANGES IN THE COMMUNICATIONS INDUSTRY

VOLUME II
DELIVERY SYSTEMS

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Final Report
Prepared for

OS/Office of Telecommunications Policy
U. S. Department of Health, Education, and Welfare
Contract No. HEW-OS-73-218

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December 1973

TABLE OF CONTENTS

Section	Description	Page
	VOLUME I	
I	EXECUTIVE SUMMARY	1-1
1.1	Introduction	1-1
1.2	Study Objectives	1-1
1.3	The Status of ITV in Secondary Schools	1-2
1.4	Future Directions for ITV	1-2
1.5	ITV Home Use: Program Market Description	1-4
1.6	Recommendations for Implementation	1-5
1.7	Delivery Systems	1-6
II	STATEMENT OF STUDY OBJECTIVES	2-1
2.1	Definition of Problem	2-1
2.2	Purpose and Scope of Research	2-1
2.2.1	Assessment of Programming and Production	2-1
2.2.2	Model of Delivery Systems	2-2
2.2.3	User Analysis	2-2
2.2.4	Program Market Description	2-2
2.3	Educational, Technical, and Economic Scope	2-3
2.4	Definition of Methodology Employed	2-4
2.5	Scheduling of Study Objectives	2-5
2.6	Data Base Utilized	2-5
III	OVERVIEW OF STATUS OF ITV IN SECONDARY SCHOOLS	3-1
3.1	Introduction	3-1
3.2	Difficulties in Assessing ITV in Secondary Schools	3-1
3.3	User Institutions: Economic Problems	3-5
3.4	User Institutions: Existing Structure of Systems and Networks	3-8
3.5	Teachers and ITV	3-10
3.6	ITV and the Communications Industry	3-16
3.7	Software Analysis	3-17
3.8	Conclusion -- The Future of ITV in Secondary Schools	3-21

00

TABLE OF CONTENTS (CONT'D)

Section	Description	Page
IV	ASSESSMENT OF FUTURE DIRECTIONS FOR ITV	4-1
4.1	Identification of Factors Inhibiting ITV's Development in the Schools	4-1
4.2	Directions for Future Implementation of ITV	4-5
4.3	Operational Requirements for ITV in the Home	4-8
4.4	Potential Structure of the ITV Market in the Home	4-10
4.5	Conclusions: Schools vs. Education	4-14
V	ITV HOME USE: PROGRAM MARKET DESCRIPTION	5-1
5.1	Introduction	5-1
5.2	Market and Financial Characteristics	5-1
5.3	Potential Demand Estimates	5-5
5.4	Program Content Requirement Estimates	5-12
5.5	Interest in Credit and Location of Learning Activities	5-14
5.6	Viability of Billable ITV in the Home	5-18
VI	RECOMMENDATIONS FOR IMPLEMENTATION OF ITV	6-1
6.1	Introduction	6-1
6.2	Need Analysis	6-1
6.2.1	Research Efforts	6-2
6.2.2	Funding	6-2
6.2.3	Testing	6-5
6.2.4	Implementation of ITV Use Nationwide	6-5
6.3	Market Development Time	6-7
6.4	Possible Roles of the Government in Implementing ITV	6-8
6.4.1	Clearinghouse Function	6-8
6.4.2	Economic Support Function	6-9
6.4.3	Copyright Clarification	6-10
6.5	Redeeming the TV Set	6-11
	APPENDIX A	

TABLE OF CONTENTS (CONT'D)

VOLUME II

Section	Description	Page
VII	DELIVERY SYSTEMS	7-1
7.1	Introduction	7-1
7.2	General Description of Delivery Systems	7-2
	Level 1	7-11
	Level 2	7-11
	Level 3	7-12
	Level 4	7-13
7.3	Detailed Description of Distribution Systems	7-14
7.3.1	Over-the-Air Broadcasting	7-16
7.3.1.1	VHF/UHF Broadcast TV	7-17
7.3.1.2	ITFS Instructional Television	7-23
7.3.2	CATV Distribution Systems	7-26
7.3.2.1	Basic CATV System Description	7-35
7.3.2.2	Two-Way Interactive Systems	7-45
7.3.2.2.1	Subscriber Response System (SRS)	7-51
7.3.2.2.2	TICCIT -- Interactive TV System	7-56
7.3.2.2.3	The Rediffusion CATV HF Distribution System	7-64
7.3.2.2.4	Computer Television Inc.	7-67
7.3.3	Special Distribution Systems	7-70
7.3.3.1	CCTV	7-70
7.3.3.2	Master Antenna TV Systems	7-70
7.3.3.3	Pay TV	7-71
7.3.3.3.1	Over-the-Air Pay TV	7-71
7.3.3.3.2	Cablecasting	7-76
7.3.4	Microwave	7-79
7.3.5	Satellite Systems	7-84
7.3.6	Home Delivery Systems - Video Tapes and Video Disc	7-93
7.3.6.1	Video Tape	7-93
7.3.6.2	Video Disc	7-94
7.3.7	PLATO (Programmed Logic for Automatic Teaching Operations)	7-96

TABLE OF CONTENTS (CONT'D)

Section	Description	Page
7.3.8	Advanced Broadband Information System	7-99
7.3.8.1	Delivery System Model	7-99
7.3.8.2	Delivery System Elements	7-103
7.4	Individual System Costs	7-130
7.4.1	CATV	7-131
7.4.2	Pay TV	7-134
7.4.3	CCTV	7-140
7.4.4	Video Disc	7-140
7.4.5	Video Tape	7-142
7.4.6	UHF Broadcast Station	7-144
7.4.7	ITFS	7-144
7.4.8	Microwave Short Haul Systems	7-149
7.4.9	Satellite System	7-152
7.4.10	TICCIT	7-154
7.4.11	PLATO	7-154
7.5	Cost Relationship Models	7-157
7.6	Decision Analysis Tools	7-160
7.6.1	Examples	7-178
	Example 1	7-178
	Example 2	7-181
	Example 3	7-185
	Example 4	7-189
7.6.2	Summary	7-193
	APPENDIX B	
	BIBLIOGRAPHY	

LIST OF TABLES

No.	Description	Page

VOLUME I

3-1	Patterns of Financial Support for ITV	3-7
3-2	New Media Devices	3-8
3-3	Audiovisual Equipment and Material Inventory of 3,142 School Buildings	3-11
3-4	Broadcast Hours of Public Television Stations	3-12
3-5	Perceptions of Restriction of ITV Service	3-14
3-6	Indicators of the Educational Market for 16 mm Films, Sound Filmstrips, and Multimedia Kits	3-18
3-7	Sales of Educational Media Materials, by Subject Areas	3-20
3-8	Relative Importance of Uses of ITV	3-23
3-9	Actual Use of ITV	3-23
5-1	Estimated Retention Rates	5-6
5-2	Instructional Sources Utilized for Adult Education	5-10
5-3	Students in Adult Basic Education	5-11
5-4	Content of Learning Interests	5-15
5-5	Percent of Adults Studying Various Topics	5-16
5-6	Credit Received by Participation in Field of Learning	5-17
5-7	Student Body and New Enrollments Home Study Education	5-20

VOLUME II

7-1	Sources/ITV Interface Guide	7-4
7-2	Quick Look Assessment Chart	7-6
7-3	Numerical Designation of Television Channels	7-18
7-4	Frequency Assignments of Instructional Television Fixed Stations	7-24
7-5	Growth of CATV Industry	7-30
7-6	U. S. Cable Systems with more than 19,000 Subscribers	7-31
7-7	CATV Systems	7-32
7-8	CATV Channel Assignments	7-41
7-9	Summary of Two-Way Cable Systems and Demonstration Projects	7-47

LIST OF TABLES (CONT'D)

No.	Description	Page
7-10	Working Allocation Plan for VHF Cables	7-48
7-11	Satellite Proposers	7-86
7-12	Broadband Information	7-104
7-13	Headend Costs	7-135
7-14	Local Origination Studio	7-136
7-15	Home Costs (Fixed Cost)	7-137
7-16	Cable Transmission Unit Costs	7-138
7-17	Pay TV Costs	7-139
7-18	CCTV Costs (Secondary School)	7-141
7-19	Video Disc Costs	7-143
7-20	Video Tape System Cost	7-145
7-21	UHF Station Costs Including Transmitter, Tower and Antenna	7-146
7-22	Other UHF Broadcast Station Cost (Fixed Costs)	7-147
7-23	UHF Broadcast Station Annual Operational Costs (Fixed Costs)	7-147
7-24	UHF Broadcast Studio Costs	7-148
7-25	ITFS Costs	7-150
7-26	Laser Link Microwave Equipment Cost	7-151
7-27	TICCIT Costs	7-155
7-28	Operational Cost of the Plato IV System	7-156
7-29	ITV System Evaluation Criteria Matrix	7-166

LIST OF FIGURES

VOLUME I

No.	Description	Page
3-1	Salaries, Current Expense Per Pupil, and Inflation 1960-1970	3-9
5-1	Percent Who Would Subscribe to Proposed Services	5-3
5-2	Willingness to Pay for Education and Library Services	5-4
5-3	Relationship of Expected Final Penetration to Monthly Subscriber Fee for Two Combinations of Services of Urban Cable Systems	5-7
6-1	5 - Year Need Analysis	6-3
6-2	ITV 5-Year Need Analysis	6-4

VOLUME II

No.	Description	Page
7-1	Overall Schematic Model of System	7-7
7-2	Educational and Other Services	7-8
7-3	Delivery System Block Diagram	7-9
7-4	ITV Activity Levels	7-10
7-5	Simplified CATV System	7-27
7-6	Market Size 2-Way Home Terminal	7-28
7-7	Master/2 Slave Headends CATV Network Interconnection	7-37
7-8	Typical Minimum CATV Local Origination Studio	7-38
7-9	Single Cable - 2-Way	7-42
7-10	2-Way, Dual Cables With A-B Switch	7-44
7-11	Switched Distribution System	7-46
7-12	SRS System	7-52
7-13	Typical SRS Communications Sequence	7-54
7-14	Computer Keyboards For Communication From Home to the Computer	7-57
7-15	TICCIT Computer Subsystem	7-63
7-16	Simplified Block Diagram	7-65
7-17	CTI System	7-69
7-18	UHF TV -- Frame Grabber Channel System	7-74
7-19	Cable Spectrum (MHz)	7-77
7-20	System Block Diagram Telebeam	7-80
7-21	Microwave Interconnects For a CATV System	7-82

LIST OF FIGURES (CONT'D)

No.	Description	Page
7-22	ITV Satellite Communications System	7-90
7-23	System Timing	7-101
7-24	Broadband Information System	7-129
7-25	CATV/Pay TV Cost Structure	7-133
7-26	Ground Station Costs and System Noise Temperature	7-153
7-27	CATV Costs per Channel Hour	7-179
7-28	Cost per Channel Hour per CATV Subscriber	7-180
7-29	Cost/Channel Hour for Added Tape Programmed Channel	7-181
7-30	Cost (Mils) per Channel Hour/Subscriber For an Added Channel, With all Tape Programming, to an Existing CATV System	7-183
7-31	Cost (Mils) per Channel Hour/Subscriber For an added Channel, With all Tape Programming, to an Existing Pay TV System	7-184
7-32	Video Disc - Cost ($) per Channel Hour per Subscriber	7-187
7-33	Total Cost per Channel 1/2 Hour for Video Disc	7-188
7-34	Cost per Channel Hour For an OTA UHF Channel	7-190
7-35	Cost per Channel Hour per Subscriber	7-191
7-36	Summary of Cost ($) per Channel Hour	7-195
7-37	Summary of Cost/Channel Hour/Subscriber	7-196
7-38	Total Costs for Adding OTA Channel to CATV System (Example 1)	7-197
7-39	Total Costs for CATV or Pay TV, Added Channel Plus Pay TV Revenue, (Example 2)	7-198
7-40	Total Cost and Revenue For 1/2 Hour Video Discs (Example 3)	7-199
7-41	30 Mile Radius OTA UHF ITV Station (Example 4)	7-200

SECTION VII

DELIVERY SYSTEMS

7.1 Introduction

The purpose of this section is to provide a detailed description of delivery systems in order that system cost-comparisons can be meaningfully structured. It describes the technical capabilities and component costs of a variety of forms of available distribution systems such as: CATV, Pay TV, CCTV, video disc, video tape, UHF broadcast, microwave systems, satellite systems, and Computer-Assisted Instruction Systems such as TICCIT and PLATO. To equip decision-makers with a consistent basis for system comparisons, the channel cost per hour per number of viewers or subscribers will be determined and plotted for several of the most significant systems described in this section.

What must be kept in mind, however, in making comparisons between different systems, is that while costs for procurement and distribution of program materials or services may be computed, means of obtaining revenue to support the distribution process often vary considerably. In some instances the viewer may pay directly for the programs he receives; in others, programming is supported by advertising revenue or is supplied at no cost to the viewer or telecaster by some third agency. Moreover, these means of support are not fixed; one delivery system may depend on a combination of resources, whereas another system of the same type may be financed by a single method. Some systems are operated to generate high profits, others are not.

What follows is a description of the different distribution systems and then a description of the system costs, followed by cost relationship models. It should be noted that though the technology described herein exists, much of it has not gone beyond the demonstration stage. As a result, the most practical cash flow procedures have yet to be determined. Thus in making decisions as to the relative desirability of alternative systems, close attention must be paid to the particular service to be delivered, to the estimated need or demand for the service, and to the system's dependency on the stability of that market for operation at a cost-effective level.

7.2 General Description of Delivery Systems

If the object of any overall system is to disseminate educational information, then it is necessary to deliver it to the user through some form of a delivery system.

The three main components of a delivery system include:

1. a means of viewing
2. a means of distribution
3. a variety of sources of information.

It is obvious that this study requires that the TV set provide the visual presentation. This means of viewing modified with specific control mechanisms must fulfill certain functions if it is going to be marketable. The consumer's access time to software must be reasonably fast and the quality of the television resolution must be high. The user must also be able to have access to the software at a convenient time, so the problem of scheduling is important. Aside from low cost, then, the technical characteristics that affect time, channel availability and quality of presentation must be taken into account when thinking in terms of demand programming -- that is, the ability to get the desired information to the consumer when he wants it. Additional accessory products for the use of single frame images will eventually be needed for access to a variety of media forms.

A distribution system is basically a way of conveying the information from the sources to the users. At present we have the external network distribution systems, including VHF/UHF broadcast, microwave, CATV, and ITFS. Internal systems include CCTV, MATV, and a variety of Pay TV configurations. The distribution system must also fulfill certain economic functions, an important one being the provision of revenue. The user might subscribe to the material through the mail, rent it from a library, buy it at a retail store, or have some device in his home that monitors what he views and bills him accordingly. Advertising pays for the distribution of video information via the networks.

Distribution systems may be either very simple or very complex. The Sony video cassette player, for example, is a very simplified form of distribution system. In order to maximize the market for program producers, a distribution system must be able to disseminate educational software on nationwide, regional, and local levels. The extension of our current external network systems to incorporate the use of satellite relay is an obvious way of expanding the information-carrying capacity of the distribution system.

Whatever the distribution system the consumer has access to, each requires that there be inexpensive equipment in the user's facility whether it be at home or in a school system, and inexpensive programs available at a central information bank. If there were an interactive two-way system with a video computer library as a central source, technically called an information storage and retrieval system, the user could obtain material in one of two ways: either by means of a dynamic programming system in which the computer requests what information the consumer wants or by means of a system in which the user himself submits his request without being polled. A central computer system that has the maximum number of home inter-connections would require a very complex time and frequency sensitive network in order to provide a multiple number of channels.

The distribution system should be capable of utilizing the many sources of information available. We want to make use of the vast amount of material available in both published media and local media. A list of published media and local media appears on the left side of Table 7-1. The table also shows the ITV elements that can be

TABLE 7-1

SOURCES ITV INTERFACE GUIDE

Published Media	ITV Interface Elements
Network TV programs	Direct TV
Commercial movies	Film Chain/Conversion to tape or disc
Professional commercials	Depends on Media
Micro publishing	Information Retrieval System
Magazine and newspaper publishing	Information Retrieval Systems
Programmed reference files	Information Retrieval Systems
Study courses	
Tape	Video Tape Player
Disc	Disc Player
Film	Film Chain or Tape
CAI	Single Frame Storage
Special purpose programs	
Tape	Video Tape Player
Disc	Disc Player
Film	Film Chain or Tape
CAI	Single Frame Storage
Wire Service data	Direct TV - Camera focused on ticker tape
Cartridge Tape (Video)	Video Tape Cartridge Player
Computer Tape	Information Retrieval - Video Tape Transfer

Local Media	ITV Interface Elements
Local TV programs	Direct TV
Advertising slides	Slide Chain
Land Camera photos	Slide Chain
16 and 8 mm movies	Telecine Unit; Slide Chain; Conversion to video tape
16 mm microfilm	Information Retrieval Systems
Microfiche	Information Retrieval Systems
4 x 6 opaque images	Slide Chain
Magnetic or paper tape	Information Retrieval Systems
Keyboard input	Via computer, Home Terminal
35 mm Slides	Slide Chain
Video	Video Tape Player

used to interface each of the sources. Thus there is a great deal of software available to be distributed by a variety of means to the user for home use via his television set.

The first part of this section provides descriptive information on the delivery systems which can be employed by HEW in disseminating educational information. A "Quick Look Assessment Chart," which is included as Table 7-2, is a prelude to the detailed descriptions that follow, so that we can develop a viewpoint about the information being presented. It is quite evident that if one is trying to determine hardware availability, choices for different applications, experimental possibilities, operational system implementation, research and development needs, the chart presented is inadequate. We can see how difficult it is to provide on one chart sufficient data to rank the systems, because of the large variety of factors involved. The chart should only be used in combination with the descriptive data that follows and the more detailed charts presented later in Section 7.6 with additional commentaries on each of the factors.

The delivery system model for ITV is represented in simplified form in Figures 7-1 to 7-3. Figures 7-1 and 7-2 represent physical concepts for an urban-suburban scene, and Figure 7-3 presents a simplified block diagram of the interconnect concepts between national, regional, and local centers. Figure 7-2 identifies additional social service interconnections.

What follows is a brief scenario as to how this system could be implemented. We see this implementation as occurring basically in four levels (Figure 7-4 illustrates these different levels.)

Level 0 -- This is where we are today. The technology exists for progress to Level 4 -- either in the laboratory or in experiments and demonstrations. ITFS, a microwave system with up to four TV channels to a school, exists in a number of areas. Educational TV is being implemented on over-the-air TV, but it has extremely limited programming and program time. CATV is developing rapidly, with installations found throughout the country. The FCC has

TABLE 7-2

QUICK LOOK ASSESSMENT CHART

Qualitative Assessment Chart	UHF	VHF	Satellite	CATV one-way	CATV two-way	ITFS	Pay TV	CCTV MATV	VTR	Video Disc	Digitized TV	TICCIT
Research & Development Required	small	no	yes	limited	yes	no	no	no	no	yes	yes	yes
Development Models Available	yes	yes	soon	yes	yes	yes	yes	yes	yes	yes	yes	yes
Experiments Conducted	yes	yes	1974	yes	yes	yes	yes	limited	yes	no	yes	yes
Production Equipment Available	yes	yes	no	yes	no	1974	yes	yes	yes	no	no	no
Marketing System In Effect	yes	yes	no	yes	no	yes	yes	no	yes	no	N. A.	no
Network Available	limited	yes	no	no	no	no	no	no	no	no	no	no
Concentrated Audiences	yes	no	no	yes	no	yes	yes	yes	yes	no	no	yes
Long Haul Capability	limited	yes	yes	no	no	no	no	no	no	no	yes	limited
Educational Distribution System Exists	yes	yes	developing	no	no	yes	limited	no	yes	no	N. A.	no
Economically Self-supporting	no	yes	long term	yes	longterm	limited	yes	yes	yes	yes	longterm	maybe
Market Responsive Programs Available	yes	yes	yes	yes	no	yes	yes	yes	limited	limited	N. A.	no
Consumer Education Required	no	no	no	no	yes	no	no	no	yes	yes	N. A.	yes
Federal Investment Required	minimal	no	yes	no	no	no	no	no	no	no	maybe	no
Private Sector Interest	minimal	yes	yes	yes	minimal	yes	yes	yes	yes	yes	yes	minimal
Capacity Available	limited	limited	large	large	limited	limited	limited	limited	large	large	limited	limited
Optimal Long-Range System	no	no	yes	yes	yes	no	yes	no	yes	yes	yes	no
Interconnection Possibilities	small	good	excellent	good	yes	good	no	yes	no	no	yes	minimal
Scheduling Flexibility	no	no	yes	yes	yes	limited	yes	no	yes	yes	N. A.	limited
Cost Effective System	no	yes	yes	yes	no	no	yes	no	yes	yes	yes	no
Probability of Success	no	no	yes	yes	yes	yes	yes	no	yes	yes	long range	limited
Standardization Possibility	none	none	yes	yes	long range	yes	no	no	yes	yes	yes	no
Other Service Extension	no	no	yes	yes	yes	no	no	yes	no	no	yes	yes

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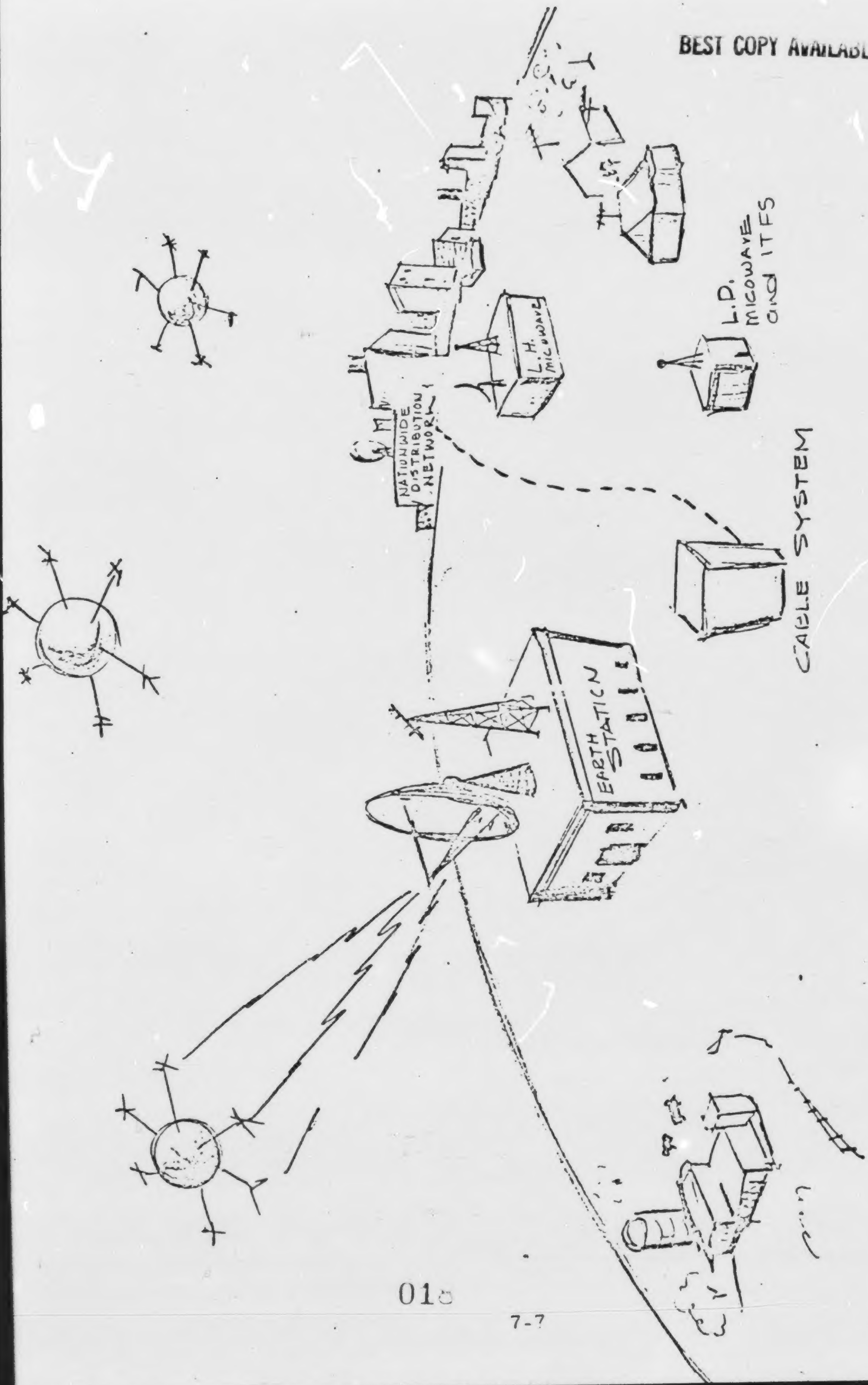
NATIONWIDE DISTRIBUTION NETWORK
L.H. MICOWAVE
L.D. MICOWAVE and ITFS
CABLE SYSTEM
EARTH STATION

Overall Schematic Model of System

Figure 7-1

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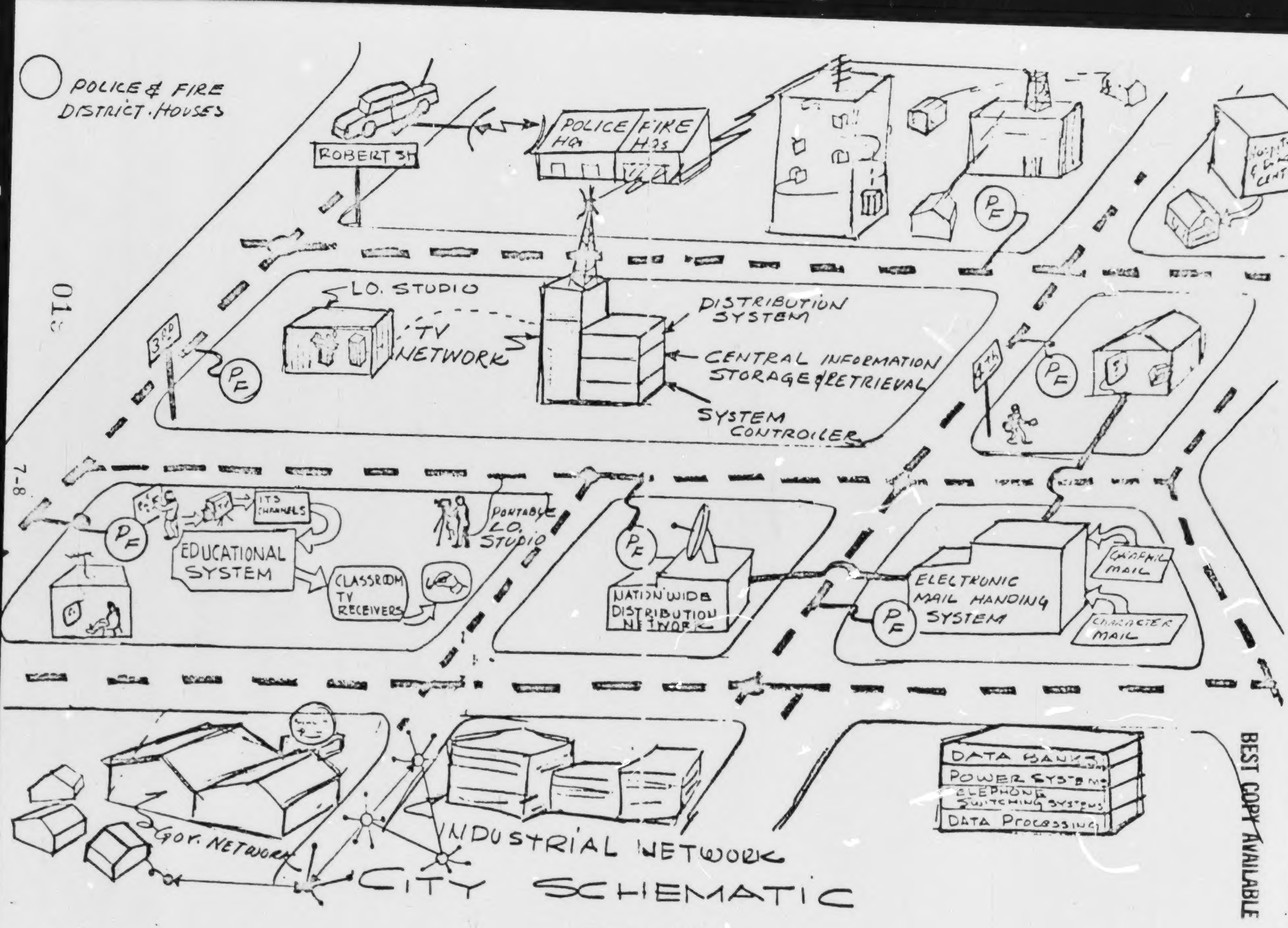
POLICE & FIRE DISTRICT. HOUSES
ROBERT St
POLICE HQ
FIRE HQs
HOSPITAL & BLOOD CENTER
PF
L.O. STUDIO
TV NETWORK
DISTRIBUTION SYSTEM
CENTRAL INFORMATION STORAGE & RETRIEVAL
SYSTEM CONTROLLER
3RD
4TH
ITS CHANNELS
EDUCATIONAL SYSTEM
CLASSROOM TV RECEIVERS
PORTABLE L.O. STUDIO
NATIONWIDE DISTRIBUTION NETWORK
ELECTRONIC MAIL HANDING SYSTEM
GRAPHIC MAIL
CHARACTER MAIL
DATA BANKS
POWER SYSTEMS
TELEPHONE SWITCHING SYSTEMS
DATA PROCESSING
GOV. NETWORK
INDUSTRIAL NETWORK
CITY SCHEMATIC

Figure 7-2
Educational and Other Services

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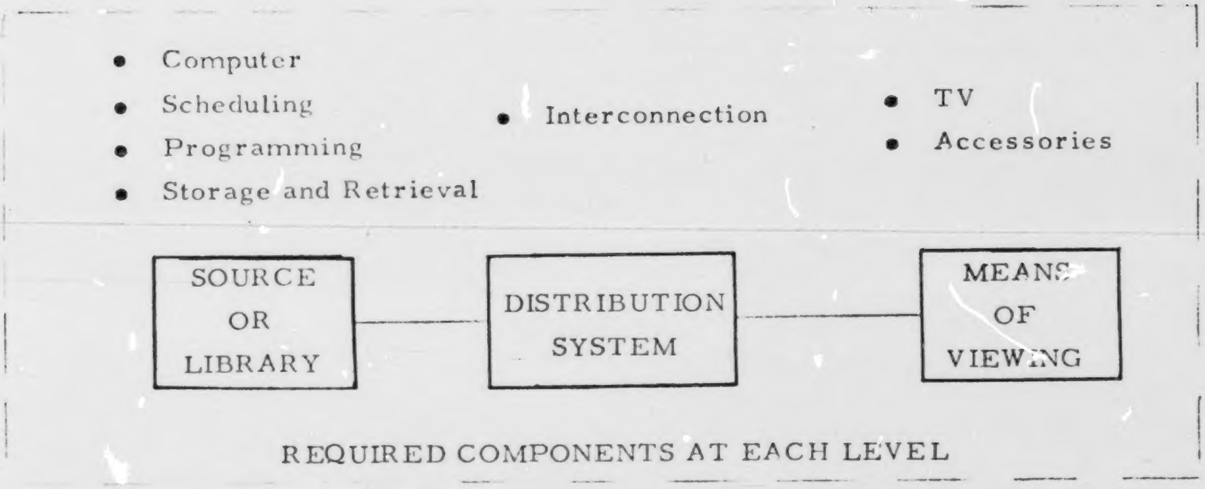

Computer
Scheduling
Programming
Storage and Retrieval
Interconnection
TV
Accessories
SOURCE OR LIBRARY
DISTRIBUTION SYSTEM
MEANS OF VIEWING
REQUIRED COMPONENTS AT EACH LEVEL

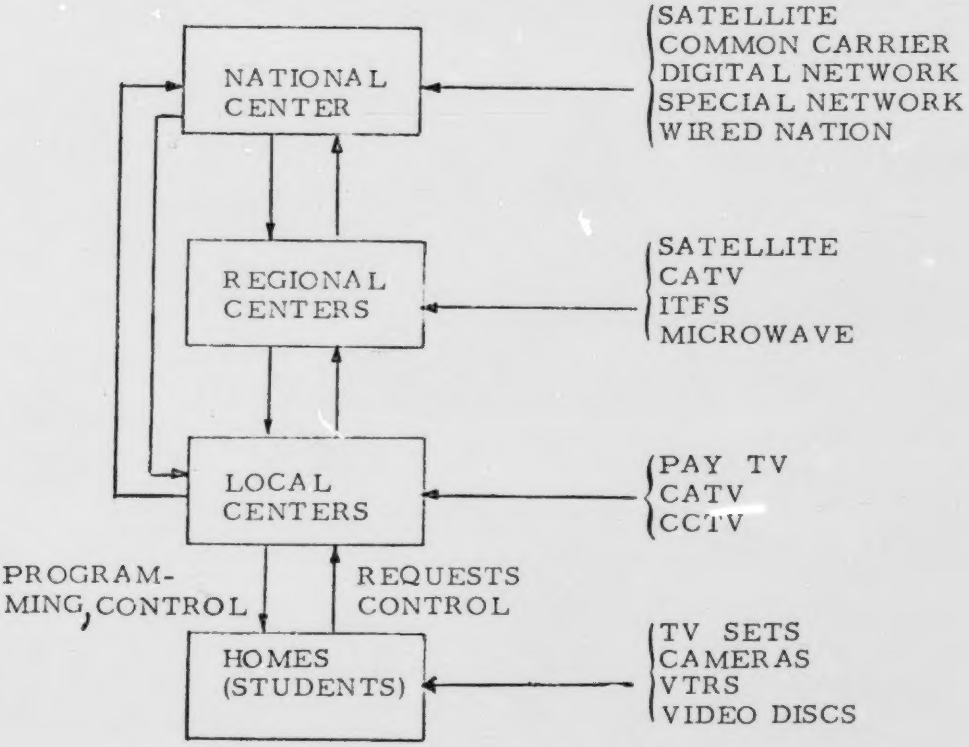
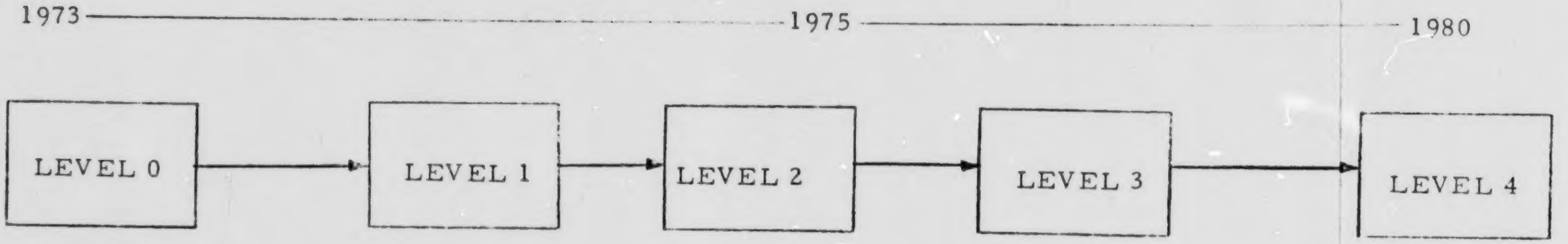

NATIONAL CENTER
REGIONAL CENTERS
LOCAL CENTERS
HOMES (STUDENTS)
PROGRAM-MING CONTROL
REQUESTS CONTROL
SATELLITE
COMMON CARRIER
DIGITAL NETWORK
SPECIAL NETWORK
WIRED NATION
SATELLITE
CATV
ITFS
MICROWAVE
PAY TV
CATV
CCTV
TV SETS
CAMERAS
VTRS
VIDEO DISCS

Figure 7-3 Delivery System Block Diagram



* UHF TV * ITFS Schools * ETV Home/Schools CATV Free time available but not used Videotape-Cassette & Video Cassette Player	CATV Pay TV ITV Video channels 1 or 2 Local Interconnect	CATV Pay TV ITV Video channels 1 or 2 Single Frame Storage (shared) Introduction of Video Disc	CATV Pay TV ITV Video Channels (4) Single Frame Storage (dedicated) CATV Local-Regional Interconnect Regional to Regional Interconnect via Satellite Video Disc and Player Cassettes and VTR	CATV/Pay TV ITV - Video Channels (5) Single Frame Storage & Retrieval CATV Local Regional and National Interconnect via Satellite Video Disc and Player Digitized TV

Figure 7-4 ITV Activity Levels

* Will continue through all levels

mandated time and channels to be available for public use, but little or no use is being made of this free service. Some implementation of ITV is occurring in the classroom, but very slowly and in few schools. Video cassettes and video cassette players are being used in schools, institutions, and industry on a limited scale for ITV. Very few video cassette players, however, are owned by individuals, owing to the cost of the player and the cost and availability of individual pre-recorded tapes. Distribution of video tapes is by mail or common carrier from distributors unless a messenger is used.

Level 1 -- The widespread implementation of CATV is progressing throughout the country and Pay TV is introduced on these systems in order to increase operator revenues and provide a wider selection of programs to the home consumer. The activity level should see the development of a 2-way interactive system and the provision of additional services through frame storage systems. And, if the programming is available, this level should also see the first introduction of ITV on the Pay TV channel for home/student selection. Payment would be either on a subscription or an individual program basis. The latter method is preferred, but it would require more sophisticated equipment than might be available at the time. The consumer status of video tape cassettes will remain the same as in Level 0, but this media will begin to replace 16 mm film as the major media used for program production. The video disc should first become available in 1975. Initial programming will be obtained from existing film libraries and will emphasize entertainment rather than instruction.

Level 2 -- Should be similar to that of Level 1 except that communications from headend to headend on a regional basis will increasingly be employed. Local program origination should be capable of occurring anywhere in the system that the local origination facility exists and then be distributed regionally. The use of computers in Pay TV systems could be extended to handle other subscriber services, which may include fire detection and alarm, burglary detection and alarm, information for frame storage channel, and interactions with the subscriber. Some ITV programming on the frame storage channel can be introduced, particularly those that can deliver individual slide-type presentations with no audio. It probably will take some time, however, to progress to this level of implementation for CATV. Although many demonstrations and experiments are presently being conducted, the widespread linkage of Pay TV to CATV-connected homes will probably take more than three or four years. These systems are relatively complex and require large amounts of initial investments for experimentation and implementation. Thus the video disc seems to have more immediate possibilities for distributing video material to the home. In this level the video disc will be used for general entertainment material geared to a mass market, whereas video tapes and cassettes will be used for more specialized productions.

Level 3 -- Assuming programming for ITV has expanded significantly, expansion of Pay TV channels dedicated to ITV should result. The single frame storage systems should be available to provide audio with slides and full pictorial capability -- not merely the text and character-filled slides of Level 2. Information storage and retrieval via video disc techniques should provide library-type capabilities and be available as a second frame storage channel. Selection would be made via an individual interactive terminal with a digital input capability used by the consumer at his location. Regional to regional interconnections of local distribution systems would be needed to provide centralized information storage and expanded programming. This interconnection of region to region will be provided by satellite communications rather than land lines because of the expense involved in the rental of those lines. The exchange of programming and resource sharing via satellite links will lead to the development of a national center for program distribution and other centralized resources. The use of video discs should increase, and users might want to retain particular ITV programs noted for their excellent quality in the same way consumers now buy LP recordings of their favorite singers or musicians. The video disc should end up as the cheapest means of program distribution for mass marketing. If an open university type system is established the parent will have an option to buy to use or store educational material as is done currently with encyclopedias.

Level 4 -- The system visualized for Level 4 provides the full capabilities of ITV distribution and delivery economically and on a national scale. A center that would have nationwide interconnections via satellite communication to regions would provide the central sources of programming. Some distribution of programming will remain on a regional basis while other programming may be geared only to local areas. If the ITV market expands sufficiently, there may be a cable in some CATV systems devoted exclusively to ITV use. Similarly a satellite system may be set up strictly for educational use. This dedicated satellite system for educational use would allow increased signal levels at the ground terminals so that a small, low-cost terminal could be utilized. This would allow individual schools or school systems to have their own satellite ground interconnections. Similarly each CATV system could afford its own satellite terminal for the reception of education and ITV programming. The switch to using digitized TV signals will be made in most if not all long-haul communication links because of equipment simplicity using large scale digital integrated circuitry with resultant cost and size reduction. Further, the capability to provide high quality video without noise accumulation is provided by means of digital communications links. At this level regional centers will contain significant computer and memory resources, which they will share with other regional centers. The video disc will be extensively used for one-way TV programming whereas the fully implemented CATV system will support Computer Assisted Instruction (CAI) with interaction by the user via a home terminal.

A low-cost video refresh-memory will be available for incorporation in the home terminal.

7.3 Detailed Description of Distribution Systems

This section of the report will describe in detail each of the distribution systems that can be used for conveying instructional television information to the public. Each of these systems is currently in use and provides a specific service that the other systems do not. The systems to be covered include:

- Over-the-Air Broadcasting
- CATV Distribution
- Special Distribution Systems
- Microwave Systems
- Satellite Systems
- Home Delivery Systems
- PLATO
- Advanced Broadband Information System

It will be quite obvious to the reader that the study results provide more data on certain types of distribution systems than on others. This was specifically done to focus on those distribution systems that lend themselves to the maximum distribution of programs in the short term and in the most economical configuration. The discussions of these distribution systems should be of value also in providing inputs to planned experiments known to be considered in the near future by organizations such as the National Institute of Health and the Department of Health, Education and Welfare. For this reason the reader will find a considerable amount of discussion of the Cable TV system and the satellite system. The report provides a considerable amount of information as well on the current effort under way on two-way interactive systems, specifically the MITRE TICCIT experiments, which are currently funded by educational organizations in the National Science Foundation.

Before discussing these systems it might be interesting to review the historical experience of the television industry. The basic industry developed around the creation and design of the means of viewing, which is the home television receiver. In order to provide information to the home receiver there was a need for the development of a means of distribution. As a result, the network system was needed and the private sector of the economy provided the development funds and entrepreneurship for both VHF and UHF broadcasting. Major investments were made by American industry in developing the first home receivers, and in the means of distribution over networks. Then it became quite obvious because of user demand that without a sufficient amount of programming the market in TV could not be sustained. So, extremely large expenditures were made in programmin of live programs. As public acceptance grew, mechanical systems for taping the presentations were provided so that programs could be re-broadcasted at a variety of centers and in a variety of locations in the United States and around the world.

To distribute these programs on a larger scale several new systems evolved, such as the satellite system for delivering TV information worldwide. The satellite systems were adequate for distribution and their capacity was essentially filled because the amount of material needed for programming was already there. When reception in communities such as mountain or rural communities was poor, new systems were needed to be able to bring reception to those communities. Dealers in remote communities had trouble selling TV sets because the networks could not deliver signals to these communities. Standard VHF TV amplifiers were initially placed on poles to deliver what is now known as CATV signals to these users. Once this new form of distribution was announced, a whole industry developed around the reception and capture of over-the-air broadcast, and delivering this information to the home. It should be recognized that these systems which are already in existence, such as the over-the-air and Cable TV systems, could be maximized and optimized for instructional TV if program material were available and put into automatic systems that require a minimum of studio equipment and personnel participation.

Other systems, such as the ITFS, evolved as the technology of microwave video systems was developed in the last five years, especially when it became evident that these systems would be needed to economize on the distribution of video information because of the high cost of telephone transmission. Estimates have been made that the three major broadcast networks were spending on the average of $145,000,000 a year purely on leased time on Bell Telephone circuits.

So, as we begin to evaluate the various systems, we notice that in their evolution there have been movements to provide more efficient technology because of the lack of cost effective distribution systems and the limited capacity to handle available program material, and that when the distribution system capacity began to exceed the availability of good program material, the private sector development effort slowed down. Efforts have to be placed in program development and user education, especially when new services need development, in order to provide an attractive market for producers of hardware and software.

Each of the following sections will include a detailed system description, some background of its relationship to ITV, and an observation of some of the problems that exist within the distribution system and which may need federal support to improve its acceptability.

Several systems have a greater likelihood than others of providing several unique functional contributions, such as:

- selective choice
- continuous and single frame video
- paid education
- world wide networking
- option to use later
- established mass distribution channels
- large channel capacity
- cost sharing

7.3.1 Over-the-Air Broadcasting

Over-the-air broadcasting for ITV programs is available in two categories, the first of which is the VHF/UHF TV channels that are presently received by the home TV receivers, and a second service called ITFS which is the broadcasting of educational information at microwave frequencies to specially-equipped users. Both of the methods of OTA broadcast are discussed below. These systems are being used today. In particular, the UHF portion of the TV allocation is underutilized for TV broadcast. There are channels which could be activated for ITV utilization if the means for economic support, the market demand and ITV programming were available.

Other services are clamoring for over-the-air spectrum, in particular Land Mobile. They have already obtained some utilization of the 470 to 512 MHz (TV channels 14 through 20) in some geographic areas (see FCC Docket 18261). Additional spectrum allocated to UHF TV also will probably be usurped by Land Mobile or others if not actively used for television service soon.

7.3.1.1 VHF/UHF Broadcast TV

Television broadcast stations are authorized for commercial and educational operation on 82 channels, as shown in Table 7-3. This service is familiar to most TV viewers for its entertainment use. The channels numbered 13 or less are termed VHF channels, and the channels numbered 14 through 83 are called the UHF channels. In addition to the commercial entertainment TV, all but three states have one or more ETV stations in operation. At the end of FY-72 there were 220 ETV stations on the air. Of these, 52 were licensed to universities, 62 to state systems, and 20 to school districts. Others were licensed to community organizations, counties, territories, and one to a city. Twenty-five applicants had construction permits outstanding and 17 more had applications pending. The FCC estimates that more than 85 percent of the nation's population is now served by educational TV.

The FCC in 1971 granted temporary authority to 15 educational TV stations to broadcast at night time specialized educational TV programs to schools which, equipped with video tape recorders, would automatically record the transmission on video tape for use during school hours. The video tape recorders were turned on and off by special address signals transmitted on the aural carrier of the television transmitter.

Rules adopted by the FCC in February of 1972 require that Cable TV systems carry all educational TV signals within 35 miles of the cable system, and also carry all educational TV stations having a Grade B contour over the cable community.

TABLE 7-3

NUMERICAL DESIGNATION OF TELEVISION CHANNELS

Channel Number	Band MHz	Channel Number	Band MHz	Channel Number	Band MHz
2	54-60	29	560-566	57	728-734
3	60-66	30	566-572	58	734-740
4	66-72	31	572-578	59	740-746
5	76-82	32	578-584	60	746-752
6	82-88	33	584-590	61	752-758
7	174-180	34	590-596	62	758-764
8	180-186	35	596-602	63	764-770
9	186-192	36	602-608	64	770-776
10	192-198	37	608-614	65	776-782
11	198-204	38	614-620	66	782-788
12	204-210	39	620-626	67	788-794
13	210-216	40	626-632	68	794-800
14	470-476	41	632-638	69	800-806
15	476-482	42	638-644	70	806-812
16	482-488	43	644-650	71	812-818
17	488-494	44	650-656	72	818-824
18	494-500	45	656-662	73	824-830
19	500-506	46	662-668	74	830-836
20	506-512	47	668-674	75	836-842
21	512-518	48	674-680	76	842-848
22	518-524	49	680-686	77	848-854
23	524-530	50	686-692	78	854-860
24	530-536	51	692-698	79	860-866
25	536-542	52	698-704	80	866-872
26	542-548	53	704-710	81	872-878
27	548-554	54	710-716	82	878-884
28	554-560	55	716-722	83	884-890
		56	722-728		

A 71 point educational TV broadcasting network was established by the Bell System in 1972, with expansion to 110 points planned for early 1973. Each TV station has its own transmitter that serves a community covered by the broadcasting radius of the transmitter. Present VHF/UHF broadcast transmitters are characterized by the use of solid state circuitry up to final stages, and a trend toward remote-controlled operation. In addition, current usage of dual or parallel operated transmitters allows higher power levels (i.e., 220 kw for UHF transmitters) and provides greater on-air reliability.

Through the use of solid state components, transmitters have become more compact, thus saving floor space, as well as providing greater equipment reliability. By use of the remote control of a transmitter, the TV station can more effectively utilize existing manpower, monitor more operational points throughout the entire television system, and automatically log the operational data. There are numerous types of VHF/UHF TV antenna designs. For each antenna certain end results are desired such as gain, vertical pattern, beam tilt, horizontal pattern, impedance and power rating. In some types of antennas these characteristics are interlocking so that compromises between these characteristics may be necessary. To support these antennas, a wide selection of television towers is available for all applications. Included are self-supporting and guyed design and also those especially designed for installation on a multi-antenna structure capable of supporting several individual TV antennas.

The major change in the TV broadcasting industry is the implementation of automaticity in many areas and functions of the station's operation. These include business automated systems, radio automation, more sophisticated remote control systems and more automation in general. RCA has provided an automated product line, including automated operation of the TK-45A camera, automatic radio transmitter, automated film cartridge projector and the TCR-100 automatic cartridge player. The automated radio transmitter will operate within FCC rules, switch to an alternate auxiliary transmitter, or shut itself off. Every one of the broadcast equipment companies is accelerating its development and production activities to provide extremely high power systems to compete with CATV for remote area coverage. The reduced costs implicit in providing the following features should have a dramatic impact in slowing down CATV acceptance in communities.

- High resolution low cost video tape systems
- Digital transmission
- Pocket-sized automated audio/video delivery systems
- Computer controlled automatically operated TV stations
- Extremely high power transmitters (UHF and VHF)
- Automatic channel selection
- Improved reliability
- Programmable video switchers
- Random production programming
- Telecine equipment
- Man pack cameras

The technology and cost improvements coupled to program deregulation will provide incentives to the broadcaster to produce educational programs.

A brief discussion on maximizing the market for VHF and UHF is needed at this point in order to understand the problem involved in providing access for educational TV information on the OTA network system.

Maximizing audience markets involves "clearing" as many commercial TV stations as possible, and the stronger the station (in audience terms) the better the return for the entire investment in programming. The problems that have to be overcome, and the recommended solutions to these problems, are described below:

- The target stations in each market are, in general, the three network affiliates, although a strong independent station (such as WNEW-TV in New York or WGN in Chicago) in some markets may hold as much audience. The target station need not be a VHF, because in some markets, such as Fresno, there are only UHF stations. The target station should be a network affiliate or other strong "raters" (the stations with large shares of their market).

a

In markets where there are only two UHF stations (such as Hartford and New Haven), which are in the unique position of dividing three networks' worth of programming over two schedules, clearance of the program will be extremely difficult, and in such cases a strong UHF alternate such as Springfield, Mass. or New Britain, Conn. (both network affiliates) should be considered.

- Stations do not want to clear what they think will be low-rated programs even if they get the program for nothing, or even if they get paid for carrying the programs. The reason for this is that stations sell their average rating to advertisers who buy spot announcements over the entire schedule. The advertiser and his agency examine the station's average rating over a week's worth of programs when comparing that station to its competition. In fact, when a particular station carries a low-rated program, the programs opposite that program on competitive stations have a chance to get larger shares of audience in the time period because the low-rated program did not garner the station's normal share of the time period. Station managers and program buyers are particularly cognizant of this and therefore will make up an excuse not to carry a program they think will be detrimental to their station's over-all audience.

  It is a good idea to do a rating analysis of the target stations in each market in order to determine the rating levels of government-sponsored programs. From this data HEW will be able to frame a "sales pitch." And further, from an examination of the entire market's audience flow, by time period, HEW will be able to recommend time periods to play the series where, even if it is a rating problem, it will not hurt the station carrying it or, conversely, will not help the competition.

- Stations do not like to give away fixed time periods (the same time and day each week) for public service programming, because it allows the competitive stations to program against that program, and thereby achieve undeserved higher ratings for weaker programs. Instead, the stations like to fill in such programming when they have, say, a rain-out in baseball, or when they want to preempt an unwanted or controversial network program.

  It is recommended that the target station be sold on the plans that in each market HEW will promote each episode heavily and we need a fixed time spot to do this promotion. There is no way that the local Alcoholics Anonymous unit, for instance, can promote the episode that would interest them if that episode were not scheduled far in advance and kept in that time slot. It is also essential to get individual educational groups to support their own particular area of expertise, so that the time period selected not be one constantly subjected to preemption.

Most companies now in the business of playing pre-paid programming will merely leave the programming at the station for play when the station has a chance to play it. This can work for subliminal advertising programming that is made by and in support of particular advertisers. There is absolutely no value in allowing the station to schedule this series, because it will be buried and/or constantly preempted, thereby negating the support behind it.

- Programs now in syndication, even programs on a barter * basis, do not clear in the 25 of the top 50 markets on the average. For HEW programs clearing as many stations as possible in the top 50 is essential, because the content of the problems dealt with in the chosen series is designed for and about that audience. In addition, you have to clear many stations below the top 50 to equal one big market audience. Further, programs that do clear, say, half the top 50 have an excellent sales pitch for clearances in the smaller markets.

  It recommended that the bulk of the effort be put against the larger markets that account for two-thirds of the TV homes in the U.S.

- It is doubtful whether advertisers would like to see their products advertised on problem-oriented programs. More than half of commercial programming has no more than 24 minutes of content to allow for six minutes of commercial time.

  It is recommended that the stations be allowed to sell these minutes on an unrestricted basis. In fact, the program contractors and HEW should jointly try to get government advertisers to buy these spots as an inducement for the target stations to carry the program.

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* Barter programs are those programs which are syndicated to stations on a free basis, with an advertiser taking generally half the commercial time in the program for himself and allowing the participating station to sell off the other half of the commercial time solely for the station's profit.

There has never been a good placement for a pre-paid public affairs series. Despite all the dollars that go into putting the content on tape, there has never been an equal effort put into getting the content in front of a large and receptive audience. This can only be achieved with the same effort that commercial advertisers use to get their high-priced programs in front of a large audience that will, in turn, buy their product and thereby return the investment that was made for the product. The information given above should also be considered when selling HEW programs to other delivery systems where profit is an important motive. A system model of UHF and TV broadcast systems providing educational information must not only consider the technology described previously but also include the costs for marketing and distributing the information to the station.

7.3.1.2 ITFS Instructional Television

In 1963 the FCC established ITFS, the Instructional Television Fixed Service, and allocated 31 TV channels, as is shown in Table 7-4, in the 2500-2700 MHz range for use by schools and universities. Typically, the in-school programs are transmitted from a single point, such as a school district headquarters, and are received by a special antenna at the schools. There the signals are translated so that they can be viewed on conventional sets in the classrooms. A single ITFS system can offer service to a school on up to four channels simultaneously.

A typical example is the four channel system used by the Diocese of Brooklyn to transmit instructional programs to over 250 schools. Several multi-channel repeaters are used to provide coverage of the entire borough. The Brooklyn system and about 100 other systems around the nation use omnidirectional transmission at microwave frequencies. With an available transmitter power output of 10 watts at 2500 MHz, omnidirectional antennas having a power gain of 15 dB, and parabolic receiving antennas giving up to 30 dB gain, path losses of about 130 dB or 20 miles can be overcome. The technology of multichannel omnidirectional microwave transmission uses standard TV for-

TABLE 7-4

FREQUENCY ASSIGNMENTS OF INSTRUCTIONAL TELEVISION FIXED STATIONS

Channel		Band Limits MHz
	Group A	
A-1		2500-2506
A-2		2512-2518
A-3		2524-2530
A-4		2536-2542
	Group A	
B-1		2506-2512
B-2		2518-2524
B-3		2530-2536
B-4		2542-2548
	Group C	
C-1		2548-2554
C-2		2560-2566
C-3		2572-2578
C-4		2584-2590
	Group D	
D-1		2554-2560
D-2		2566-2572
D-3		2578-2584
D-4		2590-2596
	Group E	
E-1		2596-2602
E-2		2608-2614
E-3		2620-2626
E-4		2632-2638
	Group F	
F-1		2602-2608
F-2		2614-2620
F-3		2626-2632
F-4		2638-2644
	Group G	
G-1		2644-2650
G-2		2656-2662
G-3		2668-2674
G-4		2680-2686
	Group H	
H-1		2650-2656
H-2		2662-2668
H-3		2674-2680

mat and frequencies, and simply translates heterodynes to the desired 2500 MHz channels. The receivers, or down-converters, consist of a preselector, a local oscillator and an amplifier covering the high band VHF Channels 7 to 13. Several CATV operators use down-converters at their cable headend to pick up special school programs or school board meetings televised by the local ITFS studio. The cost for a typical receiving installation is $1,000.

At the end of FY-72 there were 139 ITFS systems with 417 channels in operation. In addition, 45 systems with 127 channels had construction permits outstanding.

There are several major limitations to be overcome in using ITFS as part of an overall educational network system. These include:

- Channel limitation
- Power output of antennas
- Omni-directional systems
- FCC licensed for educational programming only
- Complex-costly user equipment
- Program availability - lack of resources due to no commerical sponsorship.

In order for HEW to more effectively utilize this technology it must develop the relationship of ITFS to the other communication technologies such as Cable TV, educational radio and television, common carrier and broadband transmissions, satellite, computer assisted instruction and video cassettes. As examples we include:

- Automated tape recording of programs by schools in homes during night-time broadcast hours turned on and off by special coded address signals.

- The conversion of the frequency to interface with satellite frequency assignments.

- The ascertainment of community needs by ITFS systems including software design, production, utilization evaluation and costs. The copyright and exchange practices need to be improved to provide better programs.

- The possible reallocation to frequency ranges where additional channel space is available and where other short-haul microwave interconnects could possibly be used such as MDS, and LDS systems.

7.3.2 CATV Distribution Systems

An electronic delivery system that is rapidly spreading in this country is Cable Television (CATV). Its present prime purpose is the delivery of quality TV signals to the home user. The programming provided by CATV today is entertainment, including rebroadcasting on cable the over-the-air free channels of the major networks and others. The systems use single coaxial cable and, more recently, dual coaxial cable, running from the headend of the system to each household in the familar tree configuration with trunks and branches. The headend (see Figure 7-5)of the system picks up the signal from broadcast television or from external cable systems and distributes it through the coaxial cabling network. The coaxial cables used have the capability for 20 or more TV channels on each cable. Most CATV system installers claim that they are now providing dual cable installations that can handle more than 40 TV channels and also allow 5 TV bandwidth channels per cable for return information from the user as part of interactive cable systems. Line amplifiers are inserted to make up for transmission losses (attenuation) in the cable. An adjunct to CATV is the incorporation of Pay TV and interactive two-way systems utilizing the same cables.

By 1975 Cable TV systems should pass 25% of the homes in the U. S., with 10% of the homes connected to the system. These projections of subscriber growth are shown in Figure 7-6, and were based on the following market assumptions:

- Interactive terminal market will be in systems with over 2500 subscribers;
- Penetration in these markets will build to 40% over a 5-year period;
- Systems with less than 2500 subscribers will go to less complex lower-cost equipment;
- Market will level off by 1982.

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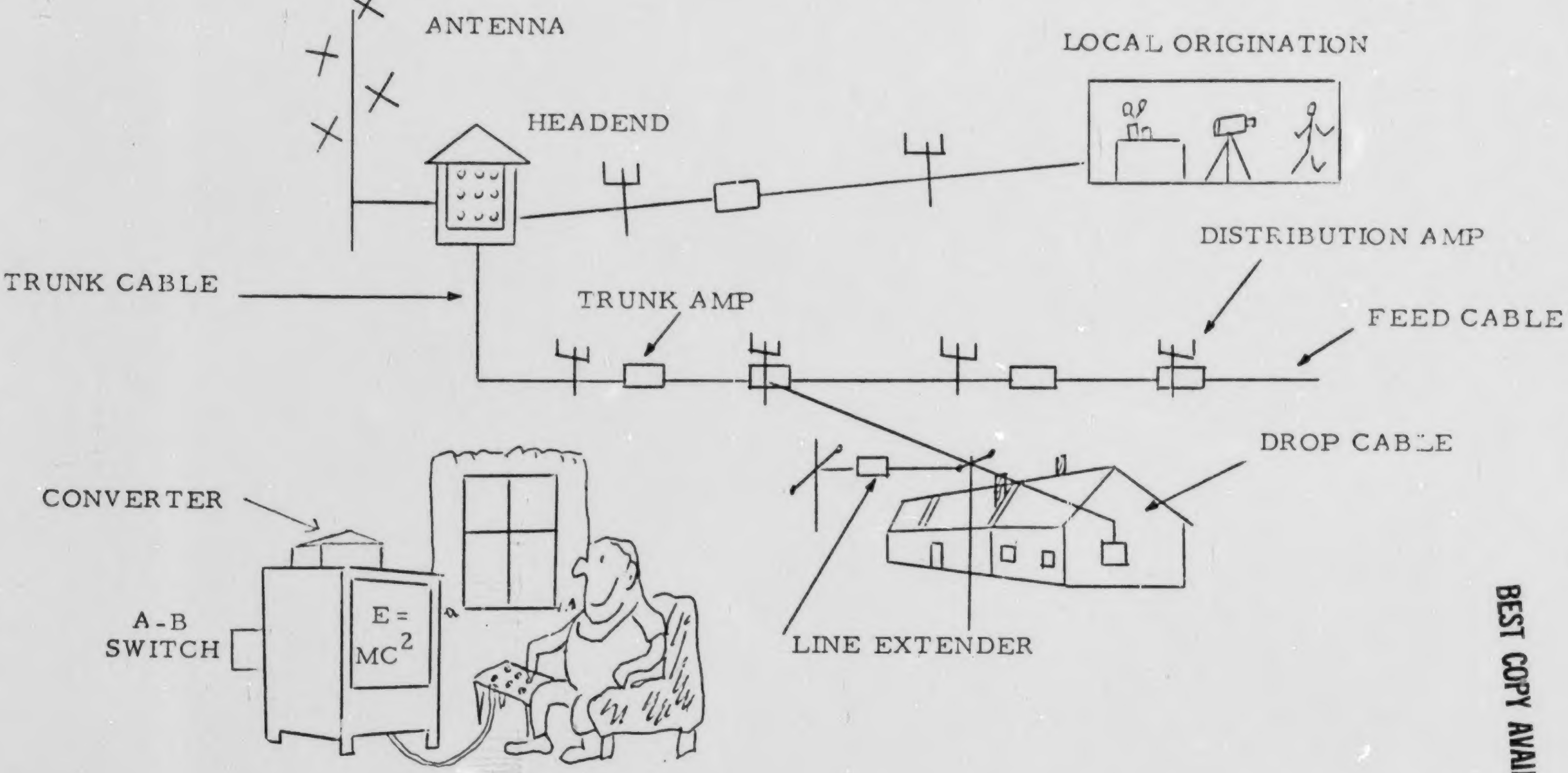
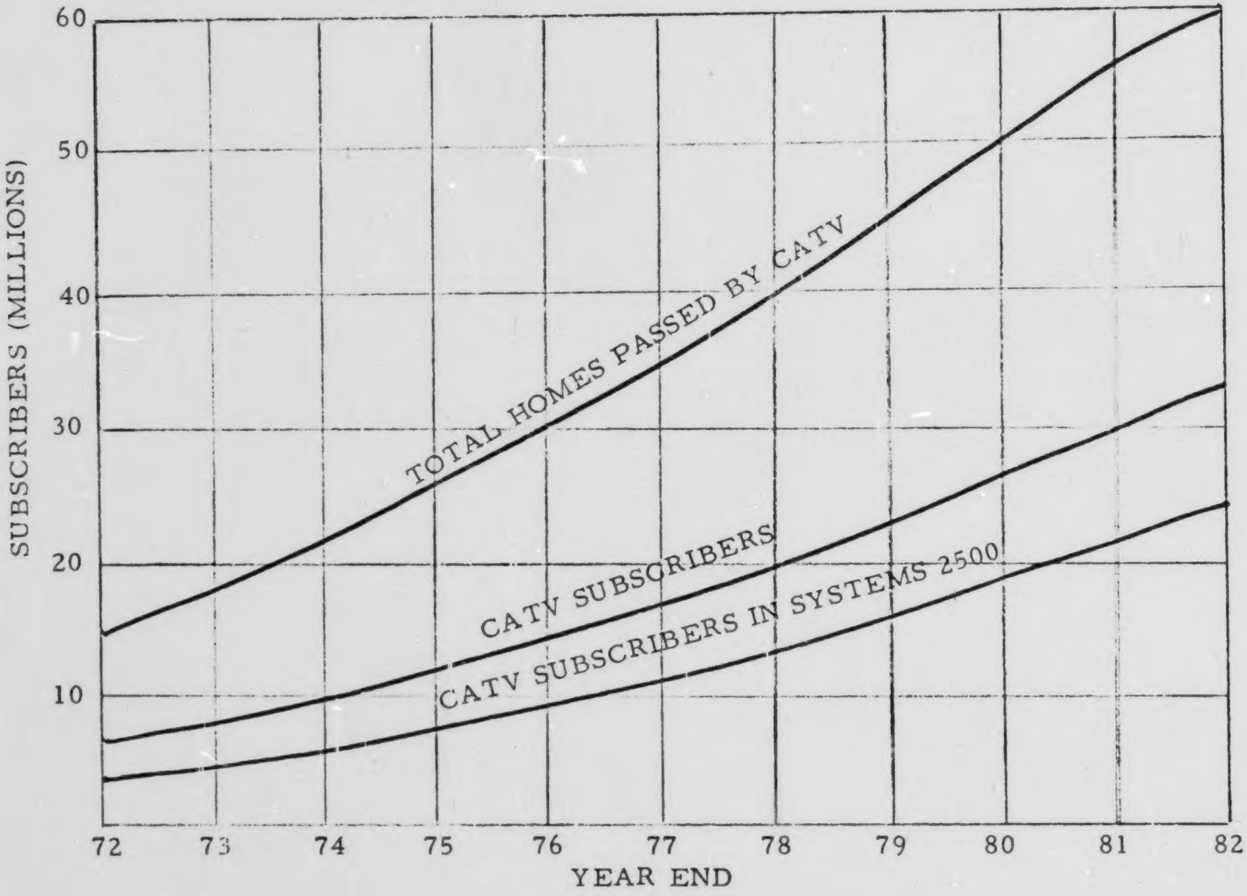

ANTENNA
HEADEND
LOCAL ORIGINATION
TRUNK CABLE
TRUNK AMP
DISTRIBUTION AMP
FEED CABLE
DROP CABLE
CONVERTER
A-B SWITCH
E = MC^2
LINE EXTENDER

Simplified CATV System

Figure 7-5



Market Size 2-Way Home Terminal

Figure 7-6

Several charts are also presented for use in evaluating the growth of the market in CATV systems. Table 7-5, which describes the growth of CA industry, follows the development of CATV systems from 1950, when the CATV first started in the United States. Table 7-6 lists the larger U.S. CATV system with more than 19,000 subscribers. Additional information on current U.S. CATV systems is shown in Table 7-7.

Today's significant expansion and use of CATV systems can be illustrated by activities at the state and local levels. In California 32 cable systems serving more than 500,000 subscribers joined forces to establish the California Cable Network, a temporary video tape distribution system coordinated through the California Community Television Association and NCTA. The network consisted of six taping and distribution centers spread throughout the state with a coordinated plan for getting tapes rapidly to participating systems. In New York City Sterling Communications is experimenting with special programming for the deaf via the existing CATV system. A special encoded signal is put on the cable together with the regular signal. A deaf viewer equipped with a special decoder gets added to his television picture an alpha-numeric display similar to a subtitle on a foreign-language movie. A regular viewer gets only the normal picture without the special display.

The FCC has required that the CATV companies set aside a percentage of TV channels for ITV. CATV is then a built-in delivery system that provides free channel space available to ITV, yet the free channel space is hardly being used. Why? First, the service is free. Therefore there is no incentive to the CATV operator to provide ITV programming. In other words there is no profit. Secondly, the availability of programs for presentation is very limited and those available are, in general, poor in quality - again owing to the small chance of making a profit in this business.

Let us assume that there is programming available, there are resources to do the market research, and there is a profit to be realized. There are several ways of using the CATV channels that are available for ITV delivery. First and simplest is the one-way TV broadcast on a CATV channel of ITV programming. As on

TABLE 7-5

GROWTH OF CATV INDUSTRY

Year	New Systems	Total Systems
1950	--	21
1951	41	62
1952	93	155
1953	119	274
1954	125	399
1955	102	501
1956	78	579
1957	69	648
1958	78	726
1959	76	802
1960	73	875
1961	89	964
1962	117	1081
1963	128	1209
1964	180	1389
1965	237	1626
1966	323	1949
1967	271	2220
1968	269	2489
1969	122	2611
1970	147	2758
1971	159	2917
1972	162	3079

TABLE 7-6

U. S. CABLE SYSTEMS WITH MORE THAN 19,000 SUBSCRIBERS

1.	San Diego, Calif. -Cox Cable	52,800
2.	New York City (Upper Manhattan), N. Y. -TPT	46,000
3.	Allentown, Pa. -Service Electric	41,300
4.	Allentown, Pa. -Twin County Trans-Video	37,000
5.	San Rafael, Calif. -Viacom	34,000
6.	New York City (Lower Manhattan), N. Y. Sterling Communications	34,000
7.	Marine County, Calif. -Tele-Vue Systems	33,896
8.	Huntsville, Ala. -TPT	32,000
9.	Santa Barbara, Calif. -Trans Video	31,000
10.	Harrisburg, Pa. -Sammons	30,185
11.	Altoona, Pa. -Cypress	26,000
12.	Los Angeles, Calif. -Theta Cable	26,000
13.	New Castle County, Del. -Rollins Cable TV	26,000
14.	Mahanoy City, Pa. -Service Electric	24,000
15.	Bakersfield, Calif. -Cypress	24,000
16.	Contra Costa County, Calif. -Viacom	23,980
17.	Kern County, Calif. -Cypress	22,800
18.	Elmira, N. Y. -TPT	22,750
19.	San Francisco, Calif. -Viacom	22,000
20.	Johnstown, Pa. -TPT	20,740
21.	Concord, Calif. -Western Communications	20,300
22.	Santa Cruz, Calif. -TPT	20,282
23.	Williamsport, Pa. -Citizens Cable	20,000
24.	Cumberland, Md. -Potomax Valley Television	19,735
25.	Utica, N. Y. -Central N. Y. Cable TV	19,430
26.	Easton-Philipsburg, Pa. -Sammons	19,425
27.	Reading, Pa. -ATC	19,410
28.	Atlantic City, N. J. -Atlantic Coast TV Cable	19,227
29.	Toledo, Ohio-Cox Cable & The Blade Co.	19,126
30.	San Jose, Calif. -Gill Cable	19,000

TABLE 7-7

CATV SYSTEMS

GENERAL INFORMATION:	
Current number of operating systems (U.S.)	3,079
Total number of subscribers served (U.S.)	6,007,815
Annual revenue from subscribers (exclusive of installation fees and extra outlet charges)	$381,376,000.00
Number of systems currently originating programs (exclusive of automatic program services)	771
THE AVERAGE U.S. CATV SYSTEM:	
Number of subscribers	2,520
Miles of plant	63
Subscribers per plant mile	40
Channels of video carried	8.8
Monthly subscriber rate	$5.29
Installation charge	$17.67

entertainment TV, a film is shown or a live broadcast is made on a regularly scheduled basis on each of the channels available. Some ITV material is amenable to this technique. The ITV program can be either on a pay basis or be supplied on a free channel. If done on a pay basis, payment would be by subscription or by the particular program viewed; or HEW can develop a program for advertising free programs as discussed in the OTA broadcast section. CATV systems are being expanded to include Pay TV systems, which include simple interactive mechanisms which can be used for the selection of and payment for desired programs. They allow for both free CATV reception and Pay TV reception at the same receiver. It is apparent that with these systems the consumer needs very little education in using the interactive terminals in obtaining his desired program.

Additional increased flexibility especially for ITV will be obtained from a single frame distribution system, a technique that is relatively new and just coming into use in conjunction with the CATV systems. A conventional TV channel has 30 frames per second broadcasted on the cable. Each frame is a single picture. In the frame snatcher system the CATV headend broadcasts on the TV channel the frames along with a control word on the control channel so that the frame can be snatched by the unit addressed by the control word. The user selects a program by means of a unit in his home that has a data entry device such as a keyboard device similar perhaps to the push-button arrangement on a phone. A large number of users can be accommodated on such a channel, since in any ten second period, for example, over 300 frames can occur. With reduced resolutions, 660 fields can be sent in the same time. If ten percent of the TV users selected this service at any one time, over 6,000 users could easily be serviced by this one channel. To control such a channel, some sort of central computer control and memory would be required. With such a system, 600 individuals could be receiving ITV material of their own choosing at any one time and at the rate they wanted.

The single frame distribution system could also be used for automatic information retrieval purposes. The information available on the channel would be indexed and referenced so that the index and reference frames could be snatched first to obtain the information available, and then to pick out and call up the information desired. Banks of microfilm cassettes, video discs or video tapes could provide the data banks to be accessed. Microfilm cassette and automatic information retrieval to the frame desired to be viewed are presently manufactured by 3M, Kodak, and Bell and Howell. Adaptation to TV use should be the next obvious step encouraged by HEW. The degree of automaticity to be obtained would depend on the size of the data bank and how many people it served. An operator at the data bank may be required during phases of evolution to higher automaticity. The frame snatcher channel is also very suitable for use in the implementation of computer assisted instruction (CAI). The TICCIT (Computer-Aided Instructional) TV system developed by MITRE and being tested in Reston, Virginia, uses frame snatching technique for the display of discrete images. With the development of the frame snatcher system, CATV would enable the user to choose from an extensive bank of programs that will consist of visual panels or slides. These programs would be running continually at regularly scheduled times so that he could watch a program at a time-interval convenient to him. This system could also be developed with an interactive capacity so that the user could signal if he wanted a frame to stop or even if he wanted to go back a frame. The technology required for this system is still in the process of being developed and it is not clear when these devices can be marketed, and whether they could be marketed at a cost that would make them attractive to a large number of users.

Thus, the CATV electronic delivery system can provide two basic forms of TV, the continuous flow of pictures, which is the conventional presentation, and the single frame (frame snatcher) distribution system, where one picture (frame) is selected out of the continuous flow of frames and is held for individual viewing. There are many variations to utilizing and implementing either or both of these two TV modes and some of these are discussed later.

7.3.2.1 Basic CATV System Description

In the modelling of a basic CATV system the basic functional elements listed below must be considered:

1. Headend
2. Headend to Headend Interconnection
3. Local Origination Studio
4. Cable Transmission System
5. Set-top Converter Home Units.

Each of the elements consists of equipment arranged to insure the capabilities of the system in the modes of operation to be provided. The simplest configuration is one in which all information originates at the headend and the local origination studio, and is transmitted by the headend downstream to the users. These cable systems utilize either single or dual cables for the distribution and are one-way (downstream only). Systems can include: (a) single coax trunks, feeders and drops; (b) dual coax trunks, single coax feeders and drops; (c) dual coax trunks and feeders and single coax drops; or (d) dual coax cable trunks, feeders and drops. The two-way CATV system has both downstream TV and data and upstream subscriber data. It is also possible to send upstream TV information from local origination sources or from other user TV camera systems. All the previously mentioned dual and multi-cable combinations can apply here also.

The headend is a central source of transmission from which a network of coaxial cabling is laid throughout an area into individual homes. In a typical headend installation, a large main antenna system is erected on a location suitable for good OTA reception. The antenna feeds signals into the system's headend - a small control station where they are tuned, amplified, and sometimes rechanneled. They are then passed into the cable. The key minimum equipment required for the CATV headend consists of the antenna system, the amplifier system, including converters, preamp, equalizer and signal processor, and other standard equipment including combining networks, audio equipment, and directional couplers and splitters.

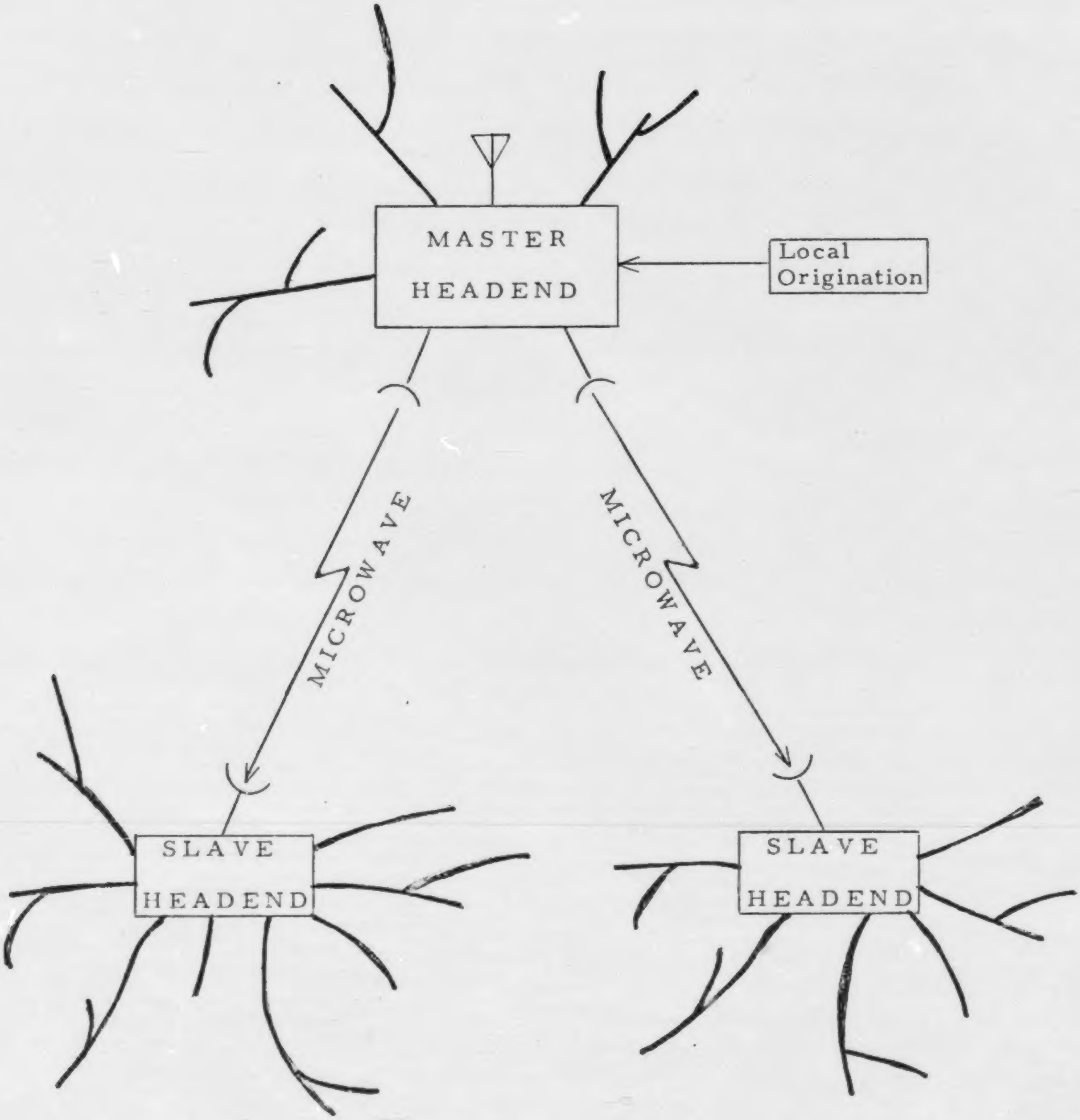
Other electronic components with applications in CATV headend operations are listed below:

Antenna Baluns
Single Channel Pre-Amplifiers
Broadband Pre-Amplifiers
Strip Amplifiers
Headend Control Units
Carrier Generators
Microwave Equipment
Demodulators
Modulators
FM Processing Equipment
Splitting and Mixing Networks
Traps and Filters
Headend Power Supplies
Non-Duplication Switchers

Another function of a headend is to distribute locally originated programs within its network. A network of headends may consist of a Master Headend and two Slave Headends tied together by microwave links. This is shown in Figure 7-7. The headends will require operators and technicians to operate the equipment. Slave headends or remotes will provide a reduction in the number of personnel required.

Unlike the large OTA network programming, the programming needed for CATV systems is generated in local origination studios. The studio may be small and simple or large and quite sophisticated. The simplest probably is the single camera focused on a digital clock and weather bulletin board which is added as a channel to the transmission system. The stock ticker or output of a wire service can also be added. A slightly more complex studio than this would be one with video tapes that could be played during the day and telecine units for the showing of movies. The next step up would be a studio that could cover live events for direct transmission or recording for later transmission. Finally, a sophisticated local origination studio could conduct live broadcasts or generate programming for later broadcast. A typical minimum CATV studio configuration is shown in Figure 7-8.

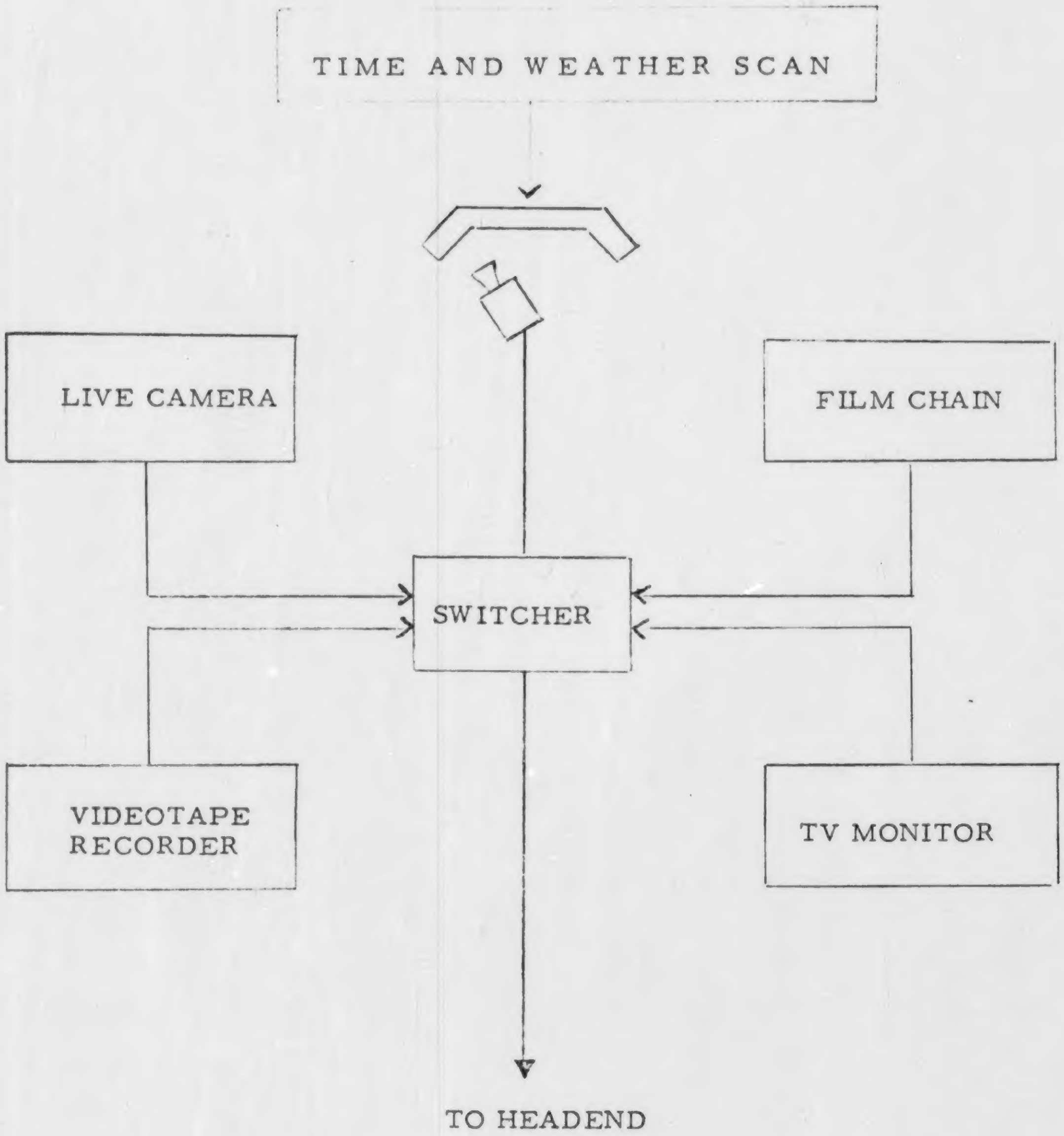
Automatic cassette cartridge players that lend themselves to reducing the operating costs in the studio are now available. Many of the local origination systems are tied into man-pack video camera systems. CATV operators are equipping communities with man-pack equipment to be used by local educational and community activities to provide programs. All of these local origination systems are an extension of the basic block diagram shown in Figure 7-8. Minicomputers are also being


MASTER HEADEND
Local Origination
MICROWAVE
MICROWAVE
SLAVE HEADEND
SLAVE HEADEND

Master/2 Slave Headends CATV

Network Interconnection

Figure 7-7


TIME AND WEATHER SCAN
LIVE CAMERA
FILM CHAIN
SWITCHER
VIDEOTAPE RECORDER
TV MONITOR
TO HEADEND

Typical Minimum CATV Local Origination Studio

Figure 7-8

added to provide automatic control of TV distribution. The future headend could become the source in the system for data transmitted via single frame distribution systems.

Cable television got its start as community antenna TV systems because it was profitable to bring good quality commercial television signals via cable to persons living in rural areas with poor broadcast television reception. Also it was found that cable television had a role to play in cities where high-rise buildings and other high-density living arrangements either precluded direct line-of-sight paths from television transmitting antennas to home receivers or caused reflections of the broadcast signals to appear on receiver screens as delayed ghosts. Cable TV solved that problem, but if the OTA broadcast signal were strong enough it could be picked up directly by a television receiver even though no receiving antenna was connected to the receiver. The same signal, delayed slightly by the cable system, can reach the receiver later than the broadcast signal and both signals can appear on the receiver screen, resulting in a "leading ghost," - and poor quality reception.

To counteract the direct-signal-pickup problem a converter can be used. It is a self-contained unit placed in a subscriber's home near the television receiver. The cable is connected to the converter and the output of the converter feeds the receiver at some unused VHF channel position. In New York City, for example, the receiver remains tuned to channel 12 at all times and the converter is used to tune in the desired CATV VHF channels. There is no direct OTA pickup by the receiver of the unused channel since there is no OTA signal being broadcast on that channel. The converter is also carefully shielded. With more-than-12-channel systems being introduced, a converter is often necessary in the subscriber's home so that the extra channels can be viewed on the subscriber's existing television receiver. A set designed for CATV use could have the extra channel capability and shielding built in so that a converter wouldn't be required, and as a result reduce a major system cost element.

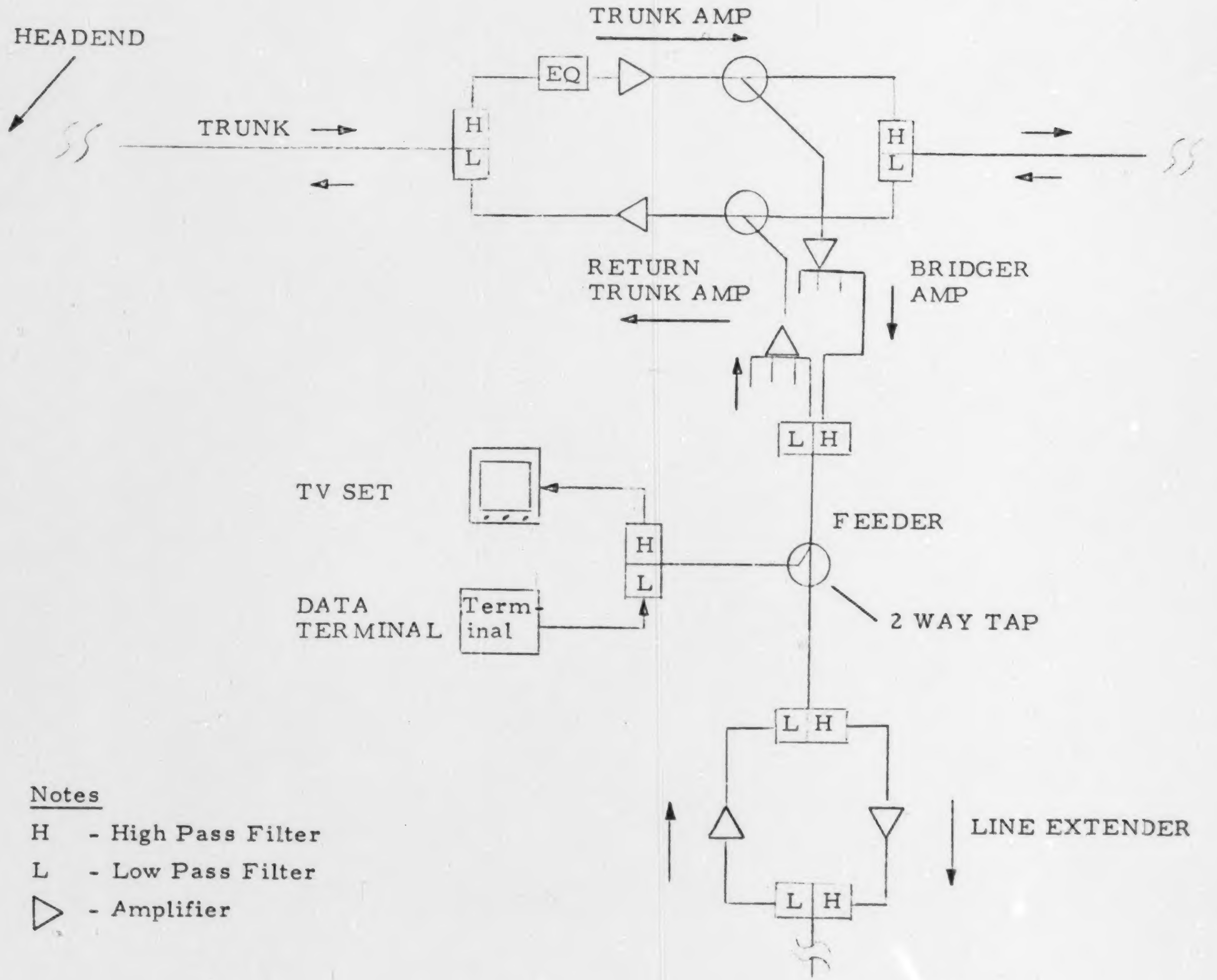
The cable transmission system provides the active interconnection of the headend and the user and also the local originating studio. There are several parts to the usual cable system. A trunk is the main coaxial cable in a CATV system between the headend - the equipment at the start of the system that receives, amplifies and processes the broadcast television signals for distribution on the system - and the community or portion of it served by the system. Included along the trunks are trunk amplifiers spaced at -20dB intervals and used to boost the signal back-up to overcome the coaxial cable losses. A feeder is the coaxial cable running between bridger amplifiers located on the trunk (including the line extenders or distribution amplifiers in the feeder system) and the taps used to obtain signal voltages from the feeder cable for subscribers. The drop cable provides the connection from the tap on the feeder cable into subscribers' homes and to the set top converter or A-B switch to which the TV receiver is connected. A simplified representation of the CATV system is shown in Figure 7-5.

The cable systems are essentially classified as single or multi-coaxial (dual the most common) and one-way or two-way. A single cable system is first described. The TV channel is frequency multiplexed onto the cable spectrum. A list of proposed CATV frequency assignments for the cable spectrum is shown in Table 7-8. To allow all the channels from 2 to P, an amplifier is required with a corresponding bandwidth to overcome cable losses. Note that the frequencies for the TV channel start at 54 MHz. The spectrum below 54 MHz isn't used. Therefore, when we desire to accomplish two-way cable operation we use frequencies of 5 MHz to 30 MHz for the return signals. The spacing between 30 MHz and 54 MHz also allows filtering to separate the downstream and upstream signals. Figure 7-9 illustrates the use of single cable and filtering to allow two-way operation. In the downstream the high pass filters block the lower frequency from the downstream amplifiers. Similarly the low-pass filters prevent the frequencies of 54 MHz or higher from entering and being amplified by the upstream amplifiers.

TABLE 7-8

CATV CHANNEL ASSIGNMENTS

Channel	Frequency Range, MHZ	Channel	Frequency Range, MHz
2	54-60	7	174-180
3	60-66	8	180-186
4	66-72	9	186-192
5	76-82	10	192-198
6	82-88	11	198-204
A	120-126	12	204-210
B	126-132	13	210-216
C	132-138	J	216-222
D	138-144	K	222-228
E	144-150	L	228-234
F	150-156	M	234-240
G	156-162	N	240-246
H	162-168	O	246-252
I	168-174	P	252-258

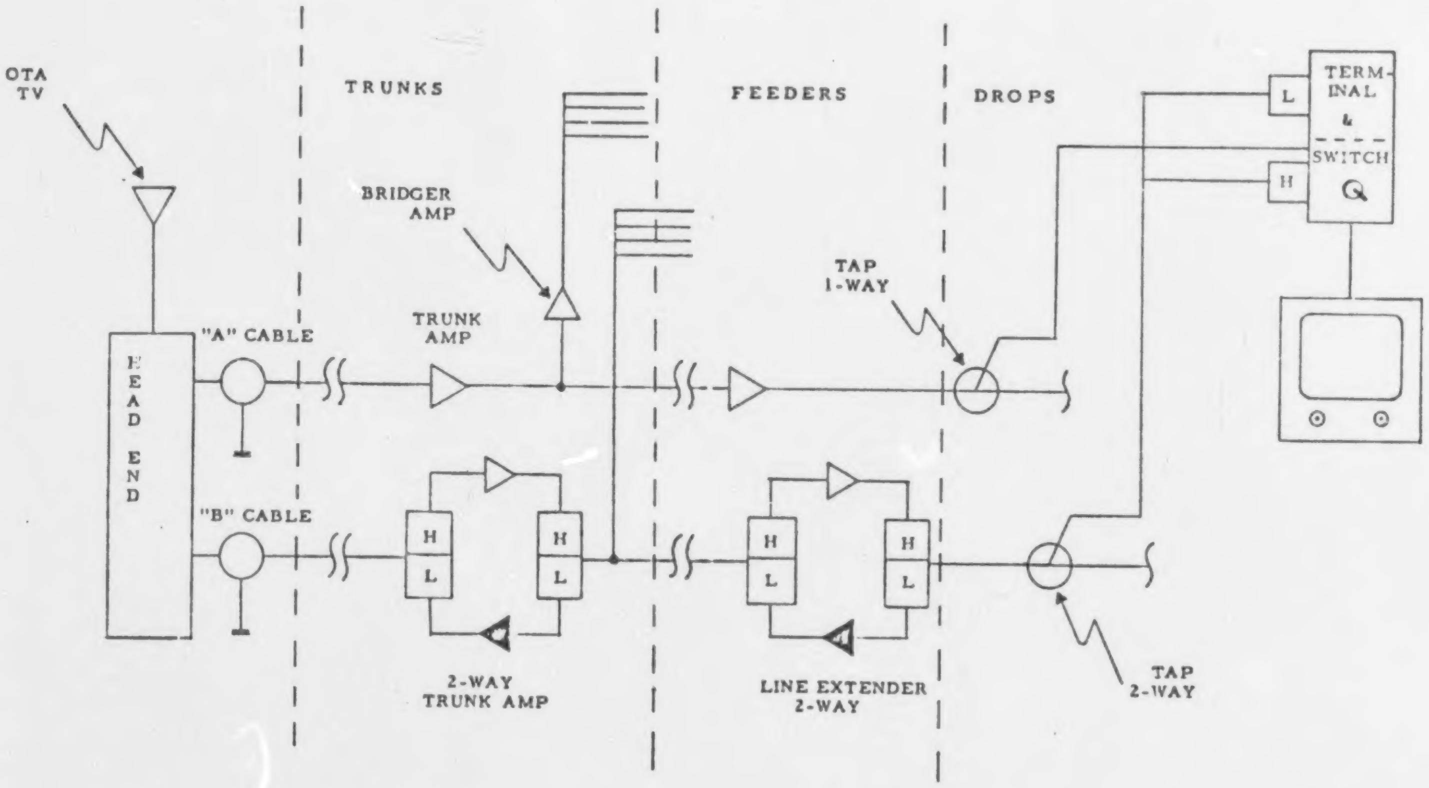

HEADEND
TRUNK
TRUNK AMP
EQ
H
L
RETURN TRUNK AMP
BRIDGER AMP
L H
TV SET
DATA TERMINAL
Term-inal
FEEDER
2 WAY TAP
LINE EXTENDER
Notes
H - High Pass Filter
L - Low Pass Filter
▷ - Amplifier

Single Cable - 2 Way

Figure 7-9

Variations of the dual-cable approach are being field-tested for two-way systems. In fact, of all approaches to increasing channel capacity with two-way feasibility, the dual-cable approach seems to be winning favor with the majority of cable system operators. Dual-cable systems may be more expensive initially than single-cable systems but they can either eliminate or reduce the amount of multiplexing necessary. As a result, there are fewer complex amplifiers, filters, and distortion problems to worry about. The dual-cable concept can be carried further, obviously, by adding a third cable, or a fourth, etc. However, economic considerations tend to rule out this approach in all but highly specialized applications or in urban areas where installation labor dominates cost and the incremental cost of multiple cable is not significant.

The simplest kind of multiple-cable transmission system is made by adding a second cable, which allows for an additional 12 VHF channels. The receiver is then equipped with a simple A-B switch. Under ideal conditions, the subscriber receives 12 standard channels in position A (assuming the channels are all being used) and 12 additional channels in position B for a total of 24. In practice, the total may be less than 24. Interference problems between cable A and cable B are much more readily controlled in such a system. Figure 7-10 shows an elementary dual trunk - dual feeder with a simple A-B switch for the subscriber.
The A cable is a conventional one-way CATV system. The B cable is a full two-way system with a return of 5-30 MHz. This configuration has all the advantages of full distribution of 20 or more channels per cable, since enough channels would be available by means of the A-B switch, and converters would not be needed. If the subscriber had a multichannel converter, he would be able to receive 42 channels (channels 2-13 and A-P on cable A plus different TV channels 2-13 and A-P on cable B).


OTA TV
TRUNKS
FEEDERS
DROPS
BRIDGER AMP
TRUNK AMP
TAP 1-WAY
TERM-INAL & SWITCH
L
H
HEAD END
"A" CABLE
"B" CABLE
H
L
2-WAY TRUNK AMP
LINE EXTENDER 2-WAY
TAP 2-WAY

NOTES:

H	High Pass Filter
L	Low Pass Filter
	Amplifier

"A" CABLE	Headend to Homes(s) VHF Channels #2-13
"B" CABLE	Headend to Homes(s) VHF Channels #2-13 Hom-(s) Back to Headend 5-30 MHz

2-Way, Dual Cables With A-B Switch
Figure 7-10

7.3.2.2 Two-Way Interactive Systems

This section will describe several alternative two-way systems that have been configured by United States equipment manufacturers. A partial listing of companies which have created two-way system configurations includes:

Jerrold-Kaiser
Scientific-Atlanta
AMECO
Rediffusion Ltd
Theta-Com
TOCOM
Video Information Systems
EIE(RCA)
VICOM
Anaconda
Mitre
GE

CATV system configurations have been affected by FCC rulings. On March 31, 1972, the FCC issued the "Cable Television Report and Order." This new FCC rule calls for new Cable TV systems in the top 100 markets to have at least 20 channels and to have built-in two-way capability on at least a non-voice basis. There are already an impressive number of experimental two-way cable systems in operation in the United States (see Table 7-9). They represent a variety of system approaches - multiplexed single cable (see Figure 7-9), dual cable (see Figure 7-10), and switched high-frequency cable (see Figure 7-11). Standardization is nowhere in evidence. In fact, the ultimate value of many of these test systems may be in proving or disproving the practicality of specific approaches. Although it is too early to impose standards, it is important that early consideration be given to this matter by HEW.

One of the questions in establishing a cable TV system is that of frequency allocation and assignment of channels on the cable spectrum. The problem arises in determining how the additional channels required by the FCC, other than the 12 TV channels assigned by the FCC for over-the-air transmission, will be delivered. And how will delivered signals interface with subscribers' television receivers? In 1971 the IEEE activated a Coordinating Committee for Cable Communication Systems (CCCCS). The Subcommittee on Frequency Allocation evaluated several basic channel assignment plans. The subcommittee adopted for its own reference one of many possible frequency-allocation plans, as is shown in Table 7-10.

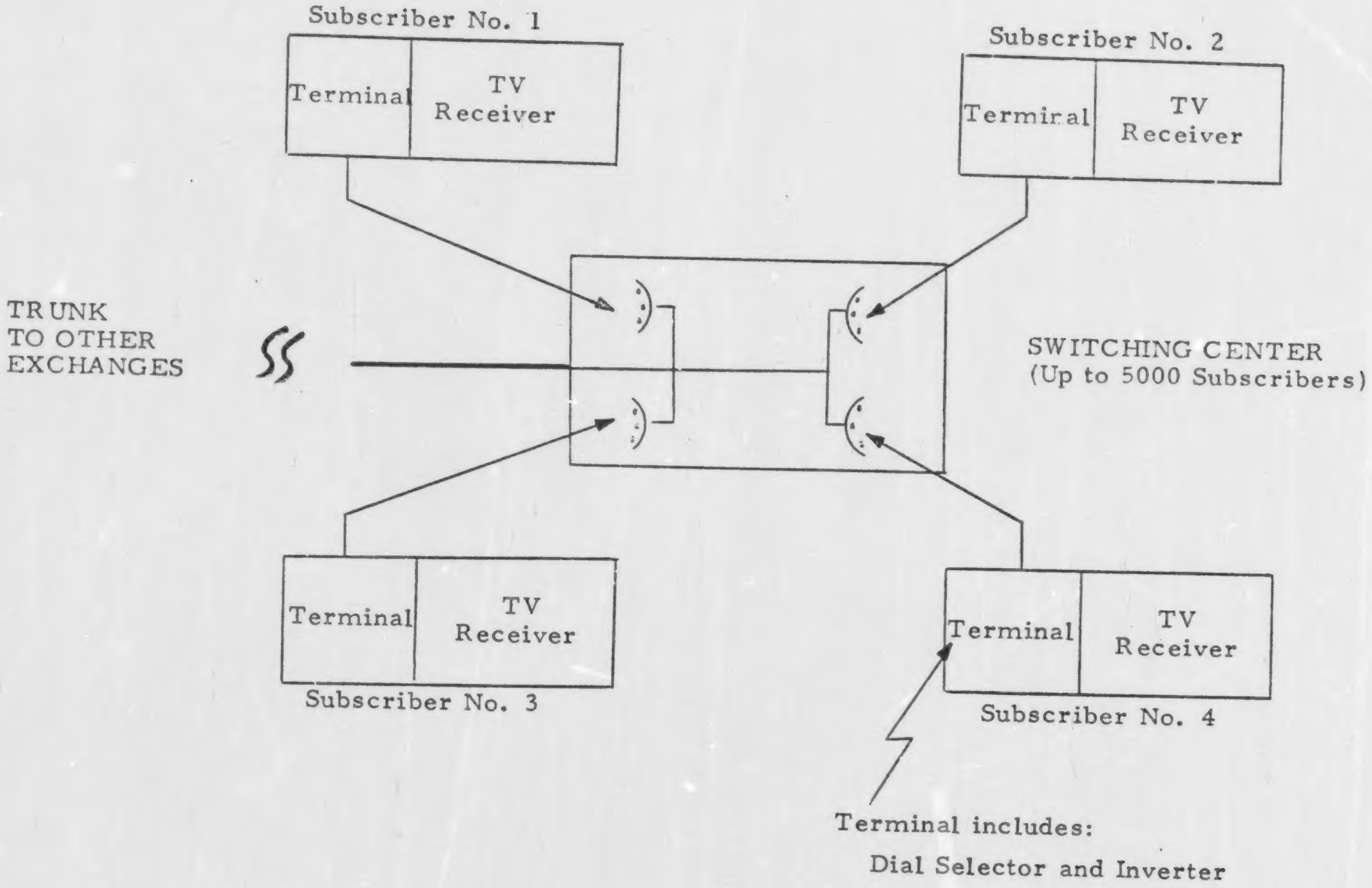

Subscriber No. 1
Terminal
TV Receiver
Subscriber No. 2
Terminal
TV Receiver
TRUNK TO OTHER EXCHANGES
SWITCHING CENTER
(Up to 5000 Subscribers)
Terminal
TV Receiver
Subscriber No. 3
Terminal
TV Receiver
Subscriber No. 4
Terminal includes:
Dial Selector and Inverter

Figure 7-11

Switched Distribution System

TABLE 7-9

SUMMARY OF TWO-WAY CABLE SYSTEMS & DEMONSTRATION PROJECTS

LOCATION	POPULATION	NUMBER OF TERMINALS	STARTING DATE	DESCRIPTION	SYSTEMS OWNER	EQUIPMENT SUPPLIER	STATUS
Akron, Ohio	275,425	---	1971	Large two-way cable installation, to date, no formal experimental plans.	TVC	Jerrold-Kaiser	No formal plans
Carpentervllle, Ill.	24,059	5	Mid-1972	Fire & burglar alarms polling subscriber, viewer habits remote connect and disconnect phase II pay TV.	LVO	Scientific-Atlanta	Limited tests
Daly City, Ga.	66,922	---	1971	Sort of R&D project to test the discade system.	Vista Grande cable vision	AMECO	No formal plans
Dennisport, Mass.	Small	---	1970	Test bed for the Rediffusion Ltd. hardware.	Leghorn Corp.	Rediffusion Ltd	Inactive
El Segundo, Calif.	15,620	30 initial 1000 later	1972	Major two-way demo for evaluating SRS services.	Teleprompter-Hughes Tool Co.	Theta-Com	Major demo.
Irving, Texas	97,260	up to 1800	Late 1973	Two-way terminals for SRS services such as: alarms pay-TV, home purchases.	Leavell	TOCOM	Major demo.
Jonathan, Minn.	4,300	Projected 50-100	1972	HUD funded, three-phase program to examine a wide range of broadband services in a planned city.	Community Information Services, Inc.	GE	Simulation
Monroe, Ga.	8,071	100	1973	Central station security system for fire and burglar alarms to be funded by LEAA.	City of Monroe	Scientific-Atlanta	Operational
New York City (Manhattan)	7,867,760	---	1971	Limited two-way over a retrofitted portion of the one-way plant.	Time-Life Teleprompter	Video Information Systems	Limited formal plans
Orlando, Fla.	99,006	25 initial 500 in 1973	1972	Major two-way demo of pay TV, security systems, merchandising, opinion polling, and credit card verification.	ATC	EIE (RCA)	Major demo.
Overland Park, Kansas	76,623	16	1971	Two-way experiment for home instruction of handicapped students. Has been expanded to include response polling, home shopping and alarms.	Tele Cable, Inc. Time-Life	VICOM Anaconda	Work nearly completed
Reston, Va.	17,000	1 - Present 400 to 1000	1971	Major two-way demo of commercial, educational & information services using frame-stopping techniques.	Warner	Mitre	Major demo.
South Orange, N. J.	16,971	Projected-4000	Late 1973	Two-way shopping, voting, polling, alarm systems both fire and burglar.	Cable Information System	Video Information System	In planning stage
Spartansburg, S. C.	44,546	---	1973	Same as Overland Park, Kansas.	Tele Cable, Inc.	VICOM	In planning stage
Sunnyvale & Oceanside, Calif.	96,000 41,000	--- ---	1972	Two-way system, to date no formal experimental plans.	FCB Cable Vision	EIE (RCA)	No formal plans

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TABLE 7-10

WORKING ALLOCATION PLAN FOR VHF CABLES

Frequency Band, MHz	Use	Possible Applications
Below 54	Experimental	Television Subscriber response signals Telemetry Facsimile Control of monitoring signals
54-72	Television	Cable television, classes I and II*
72-76	Experimental	Pilot signals Control signals
76-88	Television	Cable television, classes I and II
88-108	Aural broadcast	FM broadcast signals AM broadcast signals, remodulated to FM Local origination, FM
108-120	Experimental	Subscriber interrogation signals Control signals Pilot signals
120-174	Television	Cable television, classes I and II
174-216	Television	Cable television, classes I and II
216-270	Television	Cable television, classes I and II
270-300	Experimental	Cable television, classes I, II and III Facsimile
300-400	Experimental	Cable television, class IV Telemetry Subscriber response signals Monitoring signals
Above 400		Not allocated

* Class I - Off-the-Air Signals, Class II - origination, Class III - downstream data, Class IV - upstream data or video.

The quality of a TV picture is very important in developing interest in the use of ITV material; therefore the choice of a TV system must be based on a consideration of the following factors. In any CATV system noise and various forms of distortion are critical factors for high quality transmission of video signals. Thermal noise in the system determines the lowest signal levels that can be allowed without producing snowy pictures. Distortion products determine the maximum signal levels that can be tolerated without producing "windshield wiper" effects and "herringbone" patterns in the picture. The present state of the art limits the maximum number of amplifiers in cascade in a cable television system. Increasing the number of amplifiers above about 30 starts to lower the quality of the picture on a subscriber's television receiver beyond acceptable limits. Distortion in CATV amplifiers is caused by nonlinearities in the transistors used in the amplifiers. Distortion takes the form of cross modulation, harmonics, and/or beats. Second-order distortion products are not a problem with 12-channel systems. The standard carrier-frequency assignments established by the FCC took these distortion products into account. When more than 12 channels are being considered, however, these same distortion products become troublesome. The severity of the problem depends on the particular frequency-assignment scheme being used. The spurious signals caused by third-order distortion can give trouble in any multichannel system, since they can fall within some of the channels.

The coaxial cable used determines the attenuation that occurs along the cable. This then affects the number of amplifiers required to overcome the attenuation. A common practice is to install an amplifier at a distance that corresponds to approximately 20dB of loss. Trunks then are usually selected with large diameter, low-loss coaxial cable. Feeder cables are usually smaller in diameter than truck cables and consequently have higher losses. The drop cables into the homes from the taps on the feeder cable are generally the smallest diameter highest-loss cables used in the system. The drop cables, however, also have the shortest runs (length).

This report provides detailed information on four specific types of two-way interactive systems in order to provide information on specific differences in approach. To be comprehensive and discuss each manufacturer's equipment would make this report presentation unwieldy. Therefore we have picked this representation of systems:

SRS	Representative of different hardware manufacturers' approaches for two-way interactive systems - with different terminals and signalling techniques.
TICCIT	System using different overall system programming requirements including CAI.
Rediffusion Systems	System using HF switched distribution instead of VHF.
CTI	Computer Call-Up of programs.

Each system type can be used for different applications and networked together if a coordinated plan were developed. Each has very specific advantages and disadvantages.

7.3.2.2.1 Subscriber Response System (SRS)

The Subscriber Response System, as shown in Figure 7-12, is incorporated into a typical CATV system. The two-way communications take place between a computer complex termed the "Local Processing Center" (LPC) and the Subscriber Terminals located in the subscribers' residences or places of business. The LPC equipment can be located at the headend, at the Local Origination Studio, or remotely from the local CATV system.

Depending on the choice of location, signals between the LPC and the headend are fed by cable or microwave relay. At the headend the downstream SRS signal is frequency multiplexed with the normal CATV video spectrum and sent downstream through the cable network, including the existing trunk and distribution system.

At the subscriber's home or business location, the composite signal at the normal drop line cable is routed to the Modem Unit of the Subscriber Terminal. The Modem frequency converts a 26 channel TV spectrum and furnishes a fixed frequency signal to the TV set, normally channel 8 or 12, thus eliminating a separate frequency converter. The Modem performs all of the radio frequency modulation and demodulation and most of the digital signal processing required at the Subscriber Terminal. It also furnishes the interface for all accessories used in the system. The Modem requires no operating controls and is designed for installation at an inobtrusive location, nominally behind the TV set. All operating controls for the terminal are located at the Subscriber's Console. The Console is interconnected to the Modem by a small diameter cable which allows approximately 50 feet separation between the units, depending on the installation requirements at the subscriber's location. In addition to a TV Channel Selector Switch the Console contains a keyboard and a small strip printer allowing the subscriber to engage in two-way communications with the Local Processing Center.

Communications upstream from the Subscriber Terminal to the Local Processing Center are transmitted back from the Modem either over the same cable network with suitable upstream amplifiers

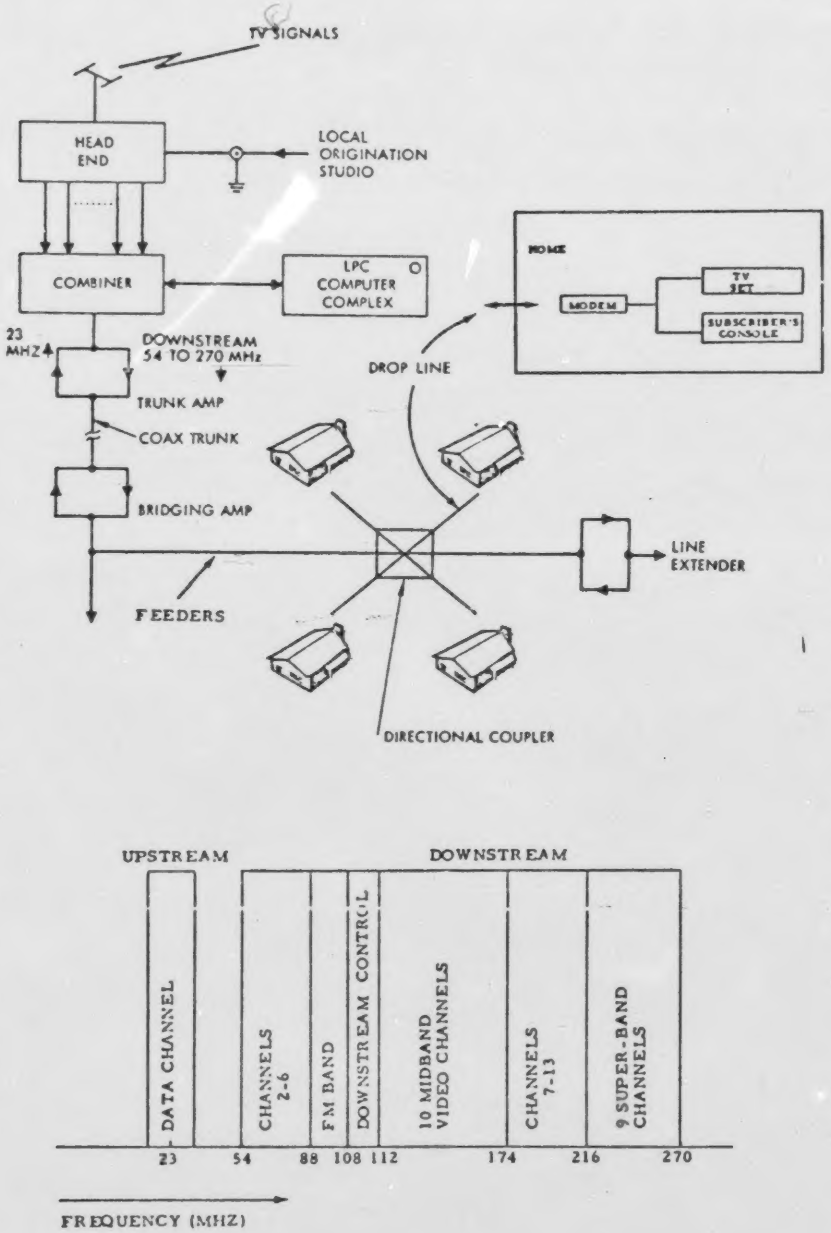

TV SIGNALS
HEAD END
LOCAL ORIGINATION STUDIO
COMBINER
LPC COMPUTER COMPLEX
HOME
MODEM
TV SET
SUBSCRIBER'S CONSOLE
23 MHZ
DOWNSTREAM 54 TO 270 MHz
DROP LINE
TRUNK AMP
COAX TRUNK
BRIDGING AMP
LINE EXTENDER
FEEDERS
DIRECTIONAL COUPLER
UPSTREAM
DOWNSTREAM
DATA CHANNEL
CHANNELS 2-6
FM BAND
DOWNSTREAM CONTROL
10 MIDBAND VIDEO CHANNELS
CHANNELS 7-13
9 SUPER-BAND CHANNELS
23
54
88
108
112
174
216
270
FREQUENCY (MHZ)

Figure 7-12

SRS System

and filter networks to by-pass the existing downstream amplifiers, or over a separate cable in a two cable system. The resulting spectrum of signals on the cable is shown in Figure 7-12. The downstream SRS signals occupy a 4 MHz bandwidth from 108 to 112 MHz. The downstream form of communication is digital pulse code modulation (PCM) at a 1 Megabit per second rate. The digital data is then used to frequency shift key (FSK) a 110 MHz carrier. The upstream signal occupies a 4 MHz bandwidth extending from 21 to 25 MHz. Again the communication is via digital PCM at a data rate of 1 Megabit per second. In this case the digital data is used to phase-shift key (PSK) a 23 MHz carrier.

A typical communications sequence that illustrates the basic principles of operation of the SRS system is shown in Figure 7-13. All communications are initiated in the Subscriber Response System at the Local Processing Center. The LPC sends an interrogation message addressed to each subscriber in sequence at a periodic rate. The meaning of the interrogation message is basically the query "Do you have requests?" The Subscriber Terminal will always reply to the interrogation with any of a number of possible requests or statements. The subscriber's replies will be sent upstream bearing the subscriber's address followed by a number of bits devoted to the content of the message. The absence of a return signal from the subscriber will indicate either a physical break in the cable path to his location or a defective Subscriber Terminal. The Local Processing Center will recognize the absence of an expected signal and take appropriate automatic action: it will post a maintenance alert for service personnel and will also flag a potential emergency alarm to cognizant police or protection agencies when such service is requested.

If a particular subscriber has initiated no requests when his terminal is interrogated, the terminal will automatically reply, giving a terminal status report. The terminal status report will indicate the state of the terminal with regard to proper functioning of the terminal circuitry, the condition of accessory devices, and other diagnostic information. The LPC will note the terminal status and take appropriate action. When a subscriber has initiated a prior request, his reply to an interrogation will indicate his address and the particular request,

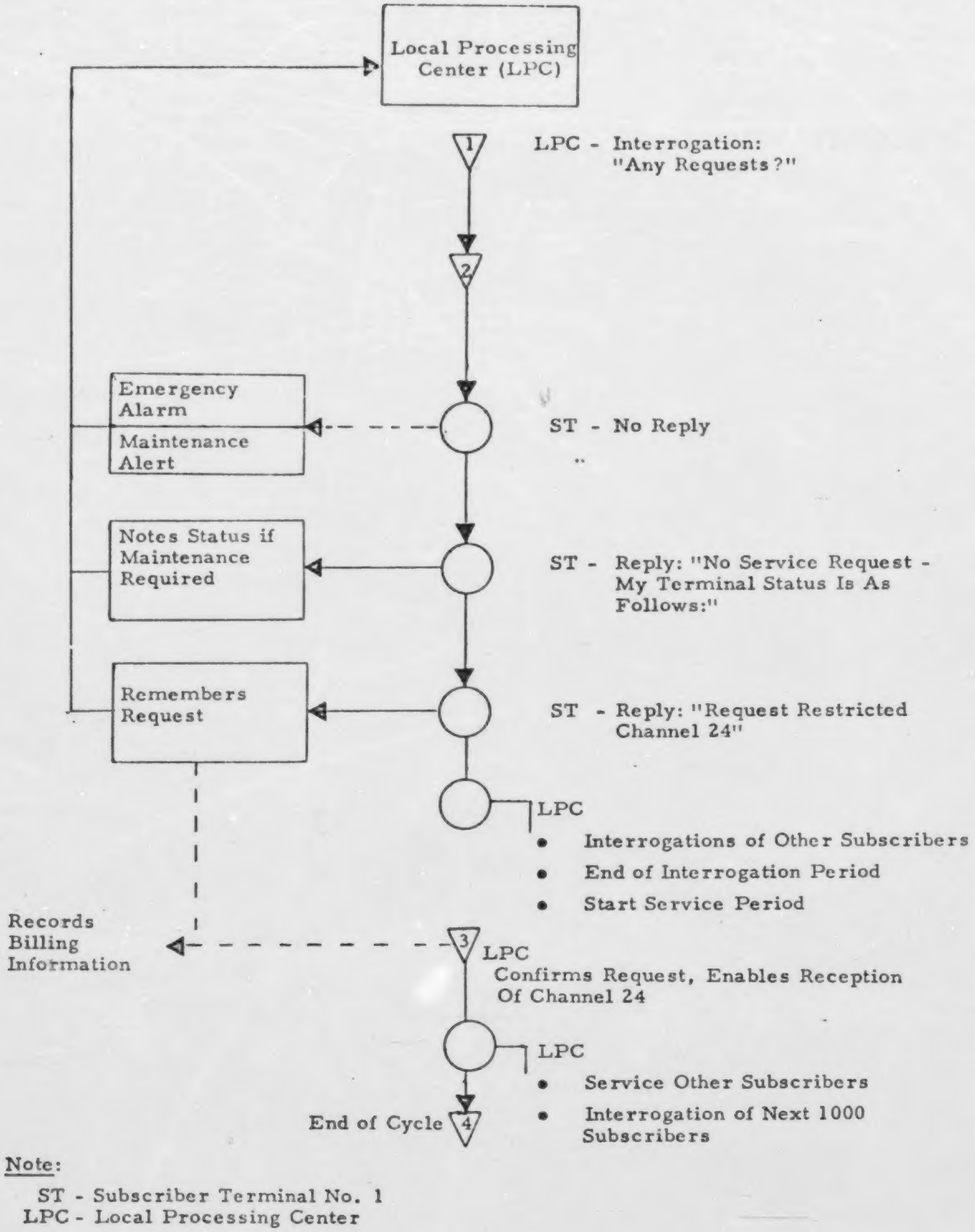

Local Processing Center (LPC)
1
LPC - Interrogation: "Any Requests?"
2
Emergency Alarm
Maintenance Alert
ST - No Reply
Notes Status if Maintenance Required
ST - Reply: "No Service Request - My Terminal Status Is As Follows:"
Remembers Request
ST - Reply: "Request Restricted Channel 24"
LPC
• Interrogations of Other Subscribers
• End of Interrogation Period
• Start Service Period
Records Billing Information
3
LPC
Confirms Request, Enables Reception Of Channel 24
LPC
• Service Other Subscribers
• Interrogation of Next 1000 Subscribers
End of Cycle
4
Note:
ST - Subscriber Terminal No. 1
LPC - Local Processing Center

Figure 7-13

Typical SRS Communications Sequence

rather than the terminal status report. In the example shown in Figure 7-13, he requests permission to view a "restricted channel," which might be programmed at that time for a medical lecture restricted to eligible doctors or other eligible professionals. In this case, the LPC will check his request and eligibility to view this program on the particular channel at that time. If the subscriber is eligible, the LPC will remember the subscriber's address for future action. If he is ineligible, the LPC will take no further action.

Each subscriber is interrogated in turn until a group of 1000 subscribers has been processed. Following the interrogation period, the LPC then services the subscriber's requests. In the case illustrated in Figure 7-13, the LPC will send a downstream message to the subscriber, thereby enabling his TV video to receive the restricted channel requested; at the same time the LPC will prepare a billing record (assuming there is a charge for this program) on magnetic tape indicating the subscriber's address, the channel requested, and the time. (Alternate information could be substituted readily for differing requirements.) At the end of the weekly or monthly billing period the magnetic tape could be used either at the LPC or another location to prepare actual billing statements for forwarding to the subscriber. When 1000 subscribers have been interrogated and serviced, the process is repeated for the next 1000 subscribers and so on. The maximum capacity provided in the present system is approximately 65,000 subscribers per Local Processing Center.

For the larger capacity systems which will eventually be required in densely populated metropolitan areas, it may prove more efficient to centralize the Local Processing Center so that it can service a number of headends. The centralized LPC would use a full-sized computer system rather than a minicomputer; it would be a faster unit with greater computing power, more storage capacity, and a greater selection of peripheral devices. Conversely the data handling equipment required at each headend would be considerably reduced. The central LPC would be interconnected with the headend two-way data interfaces by cable or microwave relay.

Two-way message capability can be initiated by a subscriber with a small numeric keyboard that is included as part of his console. Messages may be entered in groups of up to 20 characters at one time. As the subscriber enters data into the keyboard each character is printed on a paper strip so that he can check for errors and also obtain a permanent hard copy record of purchases or other financial transactions. The two-way message capability has many applications, in addition to educational instruction such as shopping at home, reservation services, stock market transactions and reports, quiz shows, elections, mail and data bank access.

7.3.2.2.2 TICCIT -- Interactive TV System

MITRE's TICCIT, Time-Shared Interactive Computer-Controlled Information Television, uses the home TV receiver as a display of computer-generated information and data retrieved from computer-controlled data bases. Communication between the home and computer is provided by a two-way cable TV system that also brings broadcast and Pay TV into the home. The home viewer can command the computer to provide information with a small keyboard like that used on a pocket calculator or he can enter information into the computer's data base with a larger typewriter-like keyboard. The kinds of consumer-oriented computer services being proposed include teleshopping, telebanking, reservations, information retrieval (such as, "When does the next bus leave for downtown?" or "What is my congressman's address?"), computer-mediated games, polls and straw votes and hospital-doctor-patient communications. It should be noted that retrievable information is not limited to text but may also include graphics, photographs, audio messages, and video tapes.

A home viewer may be inhibited in his use of certain interactive television services if he knew his neighbor could easily monitor his interactions with the computer. To provide the viewer with a reasonable degree of privacy, simple electronic signal-scrambling techniques being proposed to scramble Pay TV would be applicable to interactive television: e.g., scrambler systems, channel-shifting and address coder-decoder systems, and switching systems.

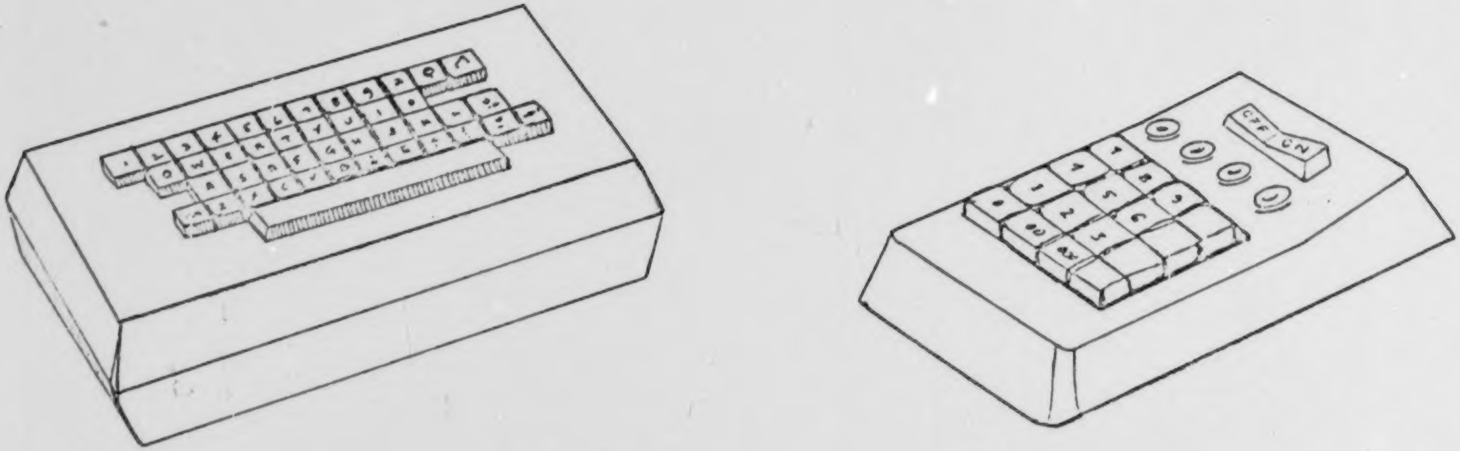


Figure 7-14

Computer Keyboards For Communication
From Home to the Computer

Two types of keyboards, see Figure 7-14, are envisioned as being used in the home, dependent upon how much and what kind of use the homeowner makes of the interactive television services. The casual user will more than likely use a small, low-cost (we anticipate the cost being about the same as the cost of pocket calculators) electronic keyboard with 12 to 16 keys. The more sophisticated user, or the person who wishes to add new information to the interactive television system data base, will have an electronic typewriter-like keyboard.

TICCIT is being demonstrated currently in Reston, Virginia, by the MITRE Corporation. Using one television channel on a wide-band cable, 600 separate television receivers can receive separate information provided by the computer at a rate of once every 10 seconds. A signal "refresh" device provided to the subscriber incorporates a video cassette recorder that allows the television screen to display the information sent by the computer at the standard television rate of 30 frames per second. By using standard telephone lines and a 12-button pushbutton phone, each subscriber can call for any kind of information the system is designed to provide, independently of all other subscribers. In the experimental system at Reston, the CATV network of the Reston Transmission Company is used. It is a dual-cable system that provides each subscriber with 12 channels on each cable. The computer for the Reston demonstration is located in McLean, Virginia. Voice and still-picture signals generated by the computer are transmitted to the headend of the Reston CATV system by microwave link. At the headend the signals are put onto channel 13 of cable A.

At the computer facility, standard telephone lines are terminated in modems that convert subscribers' information requests into a digital format. A character generator at the computer facility provides a standard television signal picture containing up to 800 characters (16 lines of 50 characters each). The character set consists of 96 alpha-numerics. Because of the characteristics of the home refresh device and the desire to maximize the use of each television channel, the demonstration system does not use the interlace feature of standard television. Instead, the transmitted picture frames contain only every other line of a standard picture, which permits sending up to 60 different pictures every second rather than 30. Address data, supplied by the character generator, are encoded near the last line of each previously transmitted picture frame as a sequence of 16 black or white elements, each measuring 1/16 of the line length. Using 16 elements allows addressing of up to 32,000 different home terminals. When a user requests information from the system, he simply dials the phone number for the computer. It signals automatically with a beep when it is ready for interactive communication. The computer then displays on the television screen a directory of services and tells the subscriber to depress the number on his pushbutton phone corresponding to the service in which he is interested. In an operational system, alternatives to pushbutton phones would be electric typewriters or other devices operating on part of the two-way cable system.

Software programs are being designed under the sponsorship of the National Science Foundation to provide individualized educational courses for home or school use. The system also provides capabilities for selective distribution of materials during "off hours." A movie or book or newspaper, for example, could be sent to a subscriber's video recorder to be stored for later display on his television receiver.

Another approach is being taken by MITRE because of the expense of the Video Refresh Memory for the home terminal. If home viewers, on the average, only use interactive television services for tens of minutes per day, another system approach is attractive. In this approach, the refresh memories are located with the display generator and the computer. Each refresh memory is connected to a different TV channel and, when the home viewer wishes to use the interactive system, he is told to tune to a channel with a then unused refresh memory. The advantage of this approach is that both the display generator cost and the video refresh memory cost are prorated over many users. The disadvantage of this approach is that it requires what, today, is an untraditional cable television system configuration, using many hubs to achieve, through space division multiplexing, the equivalent of thousands of separate TV channels in the city.

MITRE is presently implementing this approach in Reston, Virginia. Each hub would have a computer system and several trunk lines (e.g., 10) emanating from it. Each trunk would feed several hundred homes. While broadcast TV channels would be common in all trunks, each trunk would have its own set of interactive TV channels connected to video refresh memories. This hub-type configuration is also less sensitive to spurious signal pick-up than traditional tree-type configurations. The hub approach with centralized refresh appears today to be the best approach for phasing interactive television into an area, because it maximizes use of available channels and time-shares expensive equipment to reduce initial investments. After the demand for interactive television is established and the cost of home refresh memories becomes more economical, "tree" type CATV configurations could be used.

At any one time, the TICCIT system instructionally interacts with more than 100 students, each moving at his own pace through any of the CAI courses. The system retrieves student records, audio and visual information from its various data bases, and provides an audio/visual presentation for the student at his TV terminal. The student responds to the system by typing on a typewriter-like keyboard which invokes another computer-generated audio/visual presentation. Time-sharing techniques are employed in the system to allow simultaneous access to the data bases.

There are two distinct components of any CAI system: a system to allow assembling of the data bases (i.e., the conversion of the author's material into the computer data bases), and a system to deliver interactively the data bases to the students. In many developmental CAI systems, these two components have been combined into a single system. However, in the future, CAI material will most likely be prepared by professionals, packaged and sold in much the same manner as textbooks. The authoring component of the CAI system will be physically separated from the delivery components; and, in fact, the authoring component may be composed of entirely different hardware from the delivery system. For reasons of efficiency, better authoring, and the long-term approach to the generation of CAI, the TICCIT system separates authoring and delivery. MITRE's system is optimized for the delivery of CAI; however, while "off-line" (i.e. when no students are using the system), it can function as an authoring system.

TICCIT, like most other CAI systems, relies on still (not moving) computer-generated TV displays, featuring alpha-numerics and line graphics for most instructional sequences. The computer generates a new display for each student on the average of once every ten seconds; and, again on the average, the student responds with one key push every two seconds. As CAI assumes more of a role in everyday instruction, the need for variety will grow. The addition of audio-to-visual presentation will increase the student's attention span and give needed changes of pace in extensive CAI courses. Short audio messages can focus the student's attention, provide mnemonic aids, and pace learning. Moreover, audio can broaden the range of instruction for which CAI is appropriate. In this program's English course, for example, the inclusion of audio will allow the author to demonstrate differences in dialect that will enliven discussions of regionalisms and will also make testing of spelling skills possible.

The availability of color presentations of TICCIT terminals is another step toward enlivened CAI. Like the addition of sound, color will increase variety and serve as a motivational tool. Color in instructional programs can also be used to differentiate and emphasize crucial material and to prompt student responses.

TICCIT's ability to display video tapes on an individual basis at student terminals under computer control represents a cost-effective means to project any kind of motion sequence with sound and color. TICCIT's capability for the use of a mixture of video tape sequences with frame-by-frame CAI interactions is a more cost-effective approach to educating large numbers of students than attempting to store or generate all images from a central computer. Computer-graphic sequences or computer-generated animations as well as sequences with actors, language teachers, etc., that are effective can be mass disseminated through the use of video tapes.

072

MITRE's TICCIT system (controlled information television) uses color TV receivers as the student terminal display. Its pair of minicomputers (see Figure 7-15) can support over 100 active terminals. The system not only serves students in centrally located clusters of terminals, but also in dormitories, offices, and even homes off-campus through special terminals connected to the computer system via a standard cable television system. The student terminal is the most important piece of hardware in the system. It must provide a pleasant and efficient interface between the student and the computer. The terminal is composed of a color TV display, a pair of headphones, and a keyboard. The color TV displays, under computer control, alpha-numerics and line graphics in seven colors as well as full color movies. Up to 17 lines of 41 characters each may be displayed. The character set is completely programmable, with up to 512 distinct characters being definable at any single time.

The computer system separates foreground (terminal processing) and background (algorithmic frame processing) tasks with the minicomputer devoted to each task to balance and split overall system I/O channel loads. The terminal processor performs all fast-reaction, highly-stereotyped functions, interacting with the TICCIT student terminals, including frame outputting as well as keyboard input multiplexing. The main processor, utilizing the TICCIT data base, generates and assembles frames to be displayed as a function of courseware and student responses. Tasks of the main processor are diverse and relatively slow-paced.

Figure 7-16 shows how TV pictures are passed from the computer center to the TICCIT terminal. Under computer control a single character/vector generator is time-shared by all terminals. Its output (typically 1/60th of a second TV picture) is selectively passed to the video-refresh memory of the appropriate student terminal. The refresh memory repetitiously sends a single TV picture, originally generated by the character/vector generator, to its associated color TV receiver. A bank of video cassette tape players (computer directed but manually operated in the demonstration

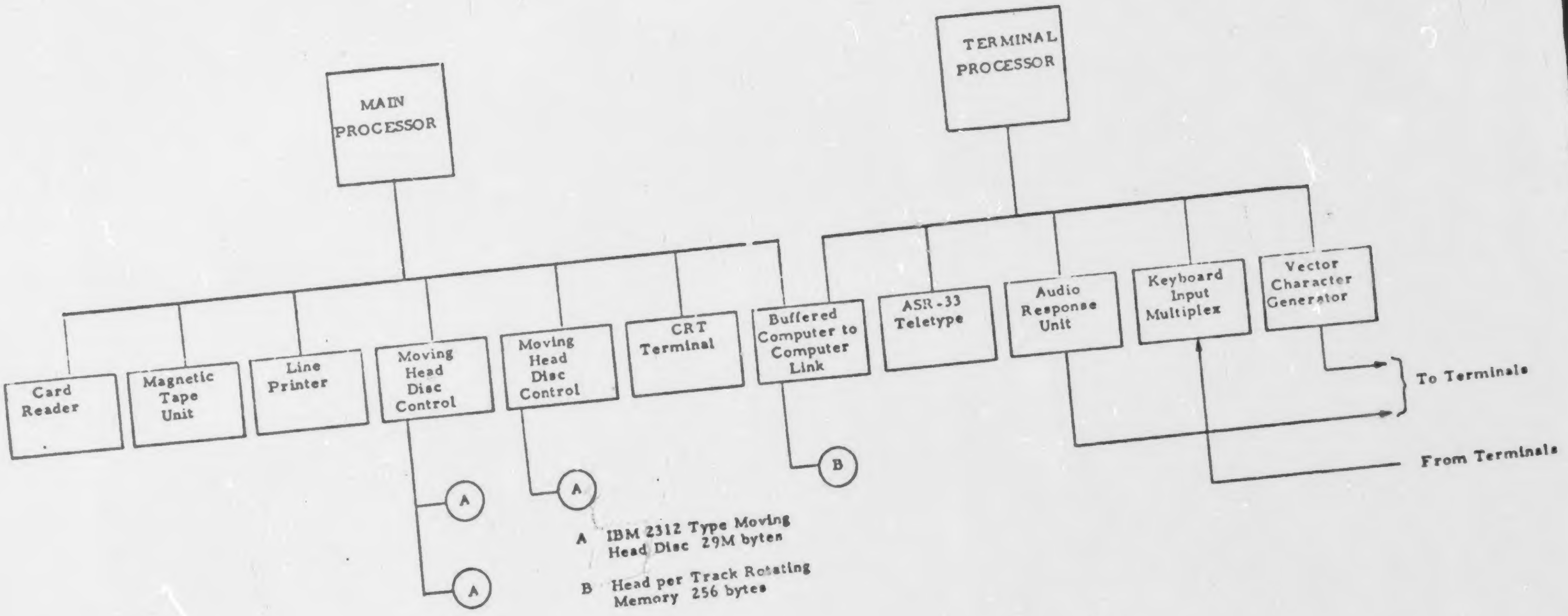

MAIN PROCESSOR
TERMINAL PROCESSOR
Card Reader
Magnetic Tape Unit
Line Printer
Moving Head Disc Control
Moving Head Disc Control
CRT Terminal
Buffered Computer to Computer Link
ASR-33 Teletype
Audio Response Unit
Keyboard Input Multiplex
Vector Character Generator
To Terminals
From Terminals
A
A
A
B
A IBM 2312 Type Moving Head Disc 29M bytes
B Head per Track Rotating Memory 256 bytes

Figure 7-15

TICCIT Computer Subsystem

systems) provides the source of full-color movies. Each TV receiver is switched to receive video either from its video-refresh memory or from a selected video-tape player. The terminals may be located up to 1,500 feet from the computer center. Audio information being sent to the terminal and keyboard signals coming to the computer are frequency multiplexed on the same coaxial cable that carries the video information to the terminal.

Several techniques to deliver CAI to the home via a cable television system have been developed and are being studied in a complementary program at MITRE. The number of terminals to operate in this mode and the technique to deliver the required signals will be a function of the availability, capability, and cooperation of cable TV systems in the vicinity of the selected community colleges.

It must be recognized that the programming and software costs for such a system for both interactive TV and CAI may be prohibitive without a private sector committment. The demonstrations to date have not provided significant user acceptance, because of the quality of the programs, and this poor quality tends to overshadow the technical advances that have been made.

The TICCIT, which is based on developing a specific engineering design for education, will require a high capital investment in order to become an operational system.

7.3.2.2.3 The Rediffusion CATV HF Distribution System

The HF TV distribution system is a hub oriented system, which can distribute up to 36 TV channels (programs) to as many as 336 outlets located with a route cable distance from the hub of 2400 feet. The number of channels can be increased to 100 if needed, with no change in the user's equipment or cabling required. The distributions are at HF so that either a twisted pair or a shielded twisted pair can be used instead of coax. The output can be to a TV monitor or a specific VHF channel of a home TV receiver. The user (teacher, etc.) is provided a selector allowing selections of any one of the 36 TV programs in addition to the over-the-air channels available to the TV receiver. Hubs may be interconnected with

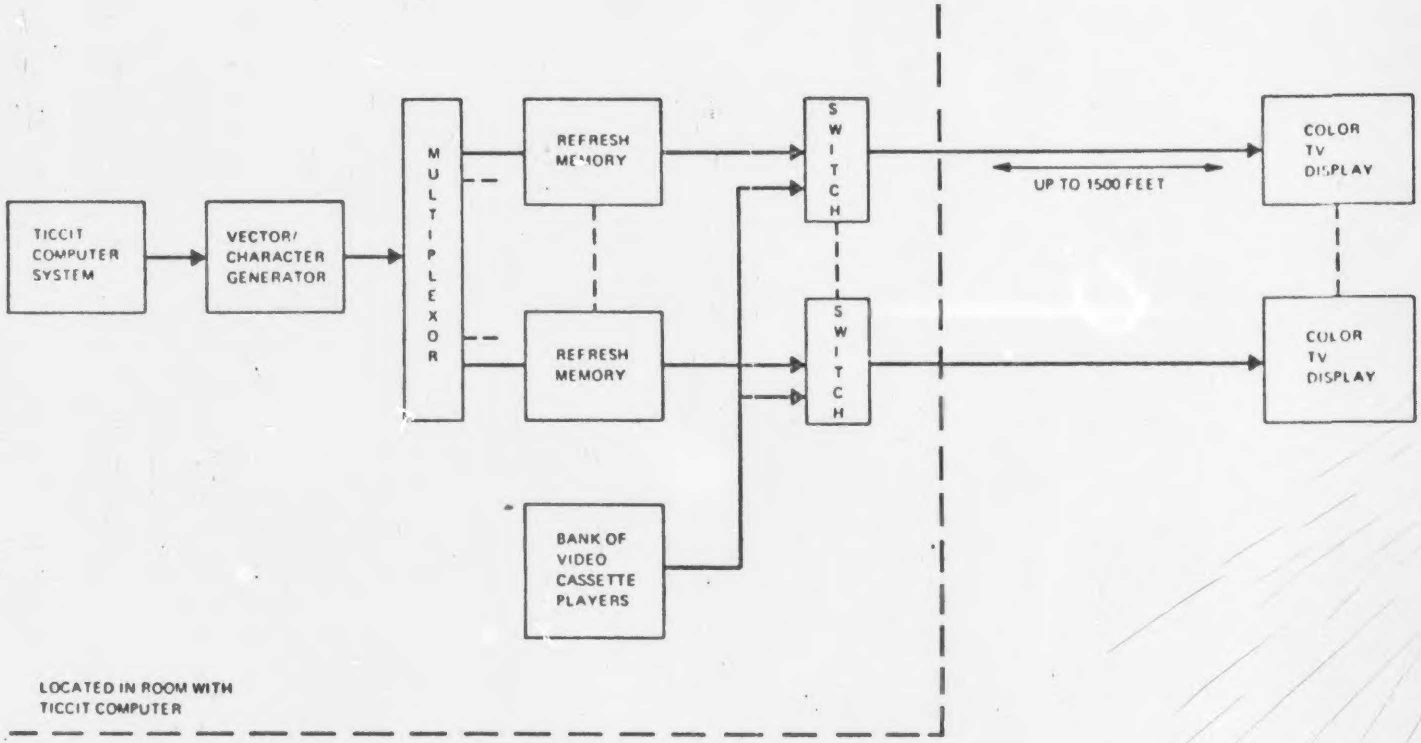

TICCIT COMPUTER SYSTEM
VECTOR/ CHARACTER GENERATOR
MULTIPLEXOR
REFRESH MEMORY
REFRESH MEMORY
BANK OF VIDEO CASSETTE PLAYERS
SWITCH
SWITCH
UP TO 1500 FEET
COLOR TV DISPLAY
COLOR TV DISPLAY
LOCATED IN ROOM WITH TICCIT COMPUTER

Figure 7-16

Simplified Block Diagram of TV Picture Generation And Transmission For Centrally Located Terminals each other by cable trunks or even microwave links into an interconnected system for school districts and regions.

A simplified block diagram of the system is shown in Figure 7-16. The trunks between hubs carry all 36 or more channels of TV programs. However, local program origination can be provided for at any of the hubs for distribution throughout the interconnected system or for use only by users served by that specific hub. The advantages of distribution at HF are that cable losses increase with frequency. Thus by using HF, longer runs of cables can be made without the need for amplifiers along the cable to boost the signal as compared to using higher frequencies at VHF and UHF. The use of twisted pair allows balanced lines and amplifiers to be used, with high common mode noise rejection a direct benefit.

The full video content up to 4.2 MHz on a 525 line program is transmitted on a carrier of 7.9 MHz. The upper sideband is vestigial and the full lower sideband is transmitted. In addition, the FM sound carrier is transmitted at the correct spacing for NTSC color 4.5 MHz below the luminance carrier, i.e., at 3.44 MHz. An additional sound signal that may or may not be associated with the vision program can also be transmitted at baseband in certain variations of the system.

The Rediffusion Company has made a significant contribution to CATV technology through the development of the HF distribution system. Unfortunately in the United States we have chosen to provide VHF television distribution as an outgrowth of first taking the over-the-air signal. The engineering departments of many companies have felt that if they had a chance in 1970 to change the direction of CATV they might have suggested to their management to develop HF Switched Systems. A major drawback is the modification to the television sets required, through the use of an inverter. The HF distribution marketing program has subsided considerably since 1972 because of the lack of interest. This system could be economical in specific school districts wired interactively together, in addition to being an internal system for schools and universities.

7.3.2.2.4 Computer Television Inc.

The term "computer call up" is used to identify systems where the user may by means of a Request Unit call up the program selection desired via a computer controlled program selector at the central location of program source material. Such s system, which has been proposed by Computer Television Inc., could be used for instructional TV -- that is, a classroom teacher could be provided with the Request Unit in addition to one or two TV receivers. With the Request Unit, the teacher then could call up the particular program selection desired for the class. The teacher may make the selection at any time during the day from the library of program material available. This system will hereafter be called the CTI system.

The CTI system will operate in the following manner:

1. Each CATV subscriber (school/teacher) will receive periodically a catalog listing the available program selections and the appropriate code number.
2. To initiate a request, the subscriber punches the code number on the top-of-the set unit. This signal is transmitted back over the cable to the computer.
3. The computer identifies the school or classroom requesting the programs, bills the school for the program (if it is pay), or bills the advertiser (if it is free with advertising) and activates the proper video tape playback unit.
4. The program is transmitted on an available CTI channel at the next half-hour or time determined by the school. In other words, if the program were requested at 9:13 a.m., it would begin at 9:30 a.m.

Some pertinent system features include:

- The program can be received only by those schools/ classrooms requesting the program.
- The system is designed so that every program is always available, no matter how often it is requested.
- While CTI utilizes many channels for its transmissions, the classroom receiver has only one setting. The system is designed so that only the proper, requested program is received. All other channels are rejected by the top-of-the-set tuner.
- Each transmitted program occupies a conventional television channel although the viewer never tunes to a particular channel. The channel is selected by the computer. These channels are currently within the capability of cable transmission, but are not utilized.
- All users can also continue receiving all the present over-the-air channels as well.

The system consists principally of five components(See Figure 7-17)

1. A CATV system converted to two-way operation.
2. A suitably programmed computer.
3. Video tape cartridge playback units, which are controlled by the computer.
4. A top-of-the-set TV tuner that is capable of receiving the program material being transmitted over special channels.
5. A unit by which CATV subscribers may request the program they wish to view.

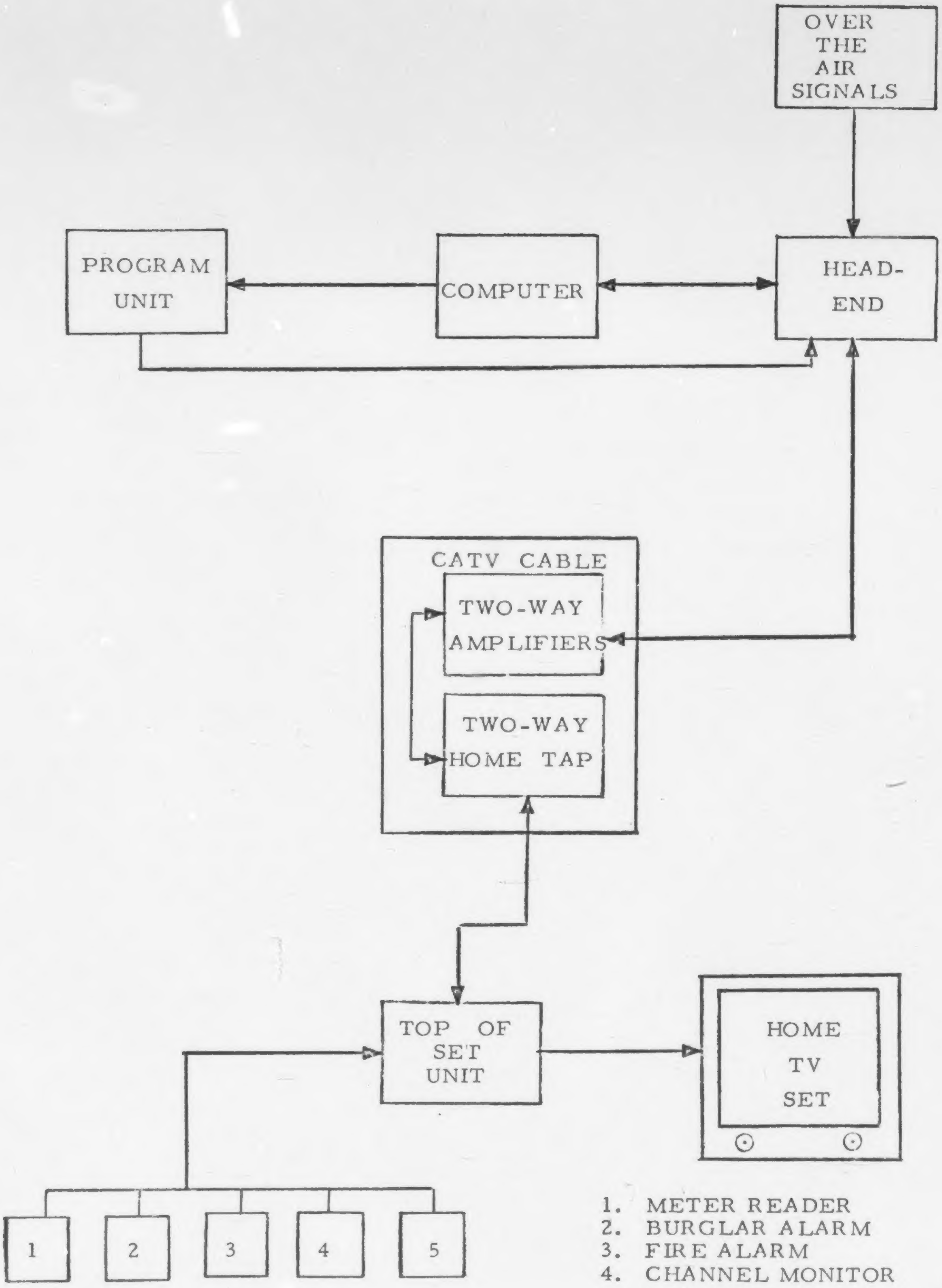

OVER THE AIR SIGNALS
PROGRAM UNIT
COMPUTER
HEAD-END
CATV CABLE
TWO-WAY AMPLIFIERS
TWO-WAY HOME TAP
TOP OF SET UNIT
HOME TV SET
1
2
3
4
5
1. METER READER
2. BURGLAR ALARM
3. FIRE ALARM
4. CHANNEL MONITOR
5. REQUEST UNIT

Figure 7-17 CTI System

7.3.3 Special Distribution Systems

This section will describe a variety of distribution systems which offer alternative means of distributing information in local areas. As a result of their need to expand their services, many of these systems will eventually link up to the CATV systems in a community.

7.3.3.1 CCTV

Closed circuit television (CCTV) is a system of transmitting TV signals to receiving equipment directly linked to the originating equipment by coaxial cable, microwave relay, or telephone lines. It differs from broadcast which is an "open circuit" tranmission of television signals through the air at frequencies which can be received by an appropriately tuned TV receiver within range of the transmitter. While the equipment used for broadcasting has to meet FCC standards, CCTV equipment does not. It is essentially downgraded broadcast equipment to do the job at reduced prices. While some of the early installations used broadcast-type equipment (particularly in the medical field), this is no longer true today. There is a wide variety of equipment available specifically designed for CCTV use with wide price ranges for specific applications.

CCTV installations run the gamut from very simple ones consisting of no more than one camera with possibly a monitor to extremely complex, multi-locational studio arrangements with switching capabilities permitting two-way audio and video communication. The basic closed circuit television systems consist of three main pieces of equipment. These are the television camera, the video tape recorder(which can also be used as a sending device after a picture has been added to the tape for the first time by means of a camera), and the reproducing device which might be a standard home-type television receiver like a television monitor.

7.3.3.2 Master Antenna TV Systems

The master antenna TV system, which is a form of CCTV, usually serves groups of subscribers such as in an apartment group, a motel, or a hotel. The system consists basically of an antenna system, the distribution amplifiers to distribute the received TV signals throughout the complex via coax cable, and taps along the cable for TV set connection. The operator of the MATV system can also generate his own program material and add this as a channel available on the cable distributing the signal to the individual room or apartment. The program material available for use by the MATV operator includes OTA programming, videotapes, time of day, messages, and announcements. The MATV operator can also use the cable spectrum for other purposes or services such as security systems, fire detection systems and room status indication.

7.3.3.3 Pay TV

Pay TV refers to any broadcasting system that requires the user to pay for the programming he wants. The user may buy either a particular program, a series of programs, or any programming within a certain period of time, depending on the payment system used. An individual card, a Pay TV terminal, a keycard, or a prepaid ticket will enable him to view these programs and will at the same time enable him to be billed for whatever he uses. Pay TV information can be delivered by either over-the-air broadcasts or cable casting.

7.3.3.3.1 Over-the-air Pay TV

Over-the-air broadcast of Pay TV scrambles the TV picture and audio by means of an encoder at the transmitter. The picture received in the home is unscrambled by a decoder which is actuated by the subscriber inserting a ticket (key card) with the proper coding on it. The home terminal allows conventional viewing of the non-pay channel except when in use to receiver the Pay TV channel. Usage is recorded on the key card and the card is returned by mail to the Pay TV operator who then bills the user accordingly. In the Blonder-Tongue system the home terminal prints a billing ticket with the charge on it. This billing ticket is mailed in monthly with a remittance. FCC approval for the over-the-air Pay TV transmission to the Greater New York and New Jersey Metropolitan area was granted to the Blonder-Tongue Broadcasting corporation. A construction permit for the TV station

(Channel 68) was simultaneously approved. The station was the first Pay TV facility to be licensed by the FCC in the United States. The proponents of over-the-air Pay TV include:

a. Pay Television Corporation, formerly TECO, the current representative of the Zenith Radio Corporation's interest in Pay TV.

b. Teleglobe Pay TV System led by Solomon Sagall. He has had periodic support from Bartell Media, Cinerama, Durwood Theatres, and others.

c. Blonder-Tongue, an equipment manufacturer guided by inventors Ike Blonder and Ben Tongue, which has fostered the BTVision concept for many years.

d. TheatreVisioN is the latest proponent, having obtained licenses from Laser Link Corporation in 1972. TheatreVisioN, known as TVN, is run by motion picture executive Dore Schary.

As of early 1973 the following applications have been filed with the FCC for over-the-air Pay TV:

Boston: Boston Heritage Broadcasting, WQTV, Channel 68.

Chicago: WCFL-TV, Channel 28, now being transferred to Pay Television Corporation.

Detroit: WJMY-TV, Channel 20.

Newark: Blonder-Tongue Broadcasting, which was granted a construction permit for WBTB-TV, Channel 68, July 26, 1972.

Philadelphia: Vue-Metrics is now applying for vacant Channel 57. (The original application was for Channel 23).

Philadelphia: Radio Broadcasting Company is applying for Channel 57.

San Francisco: Lincoln Television, KTSF-TV, Channel 26.

Sacramento: Applications are in process.

Los Angeles: Applications are in process.

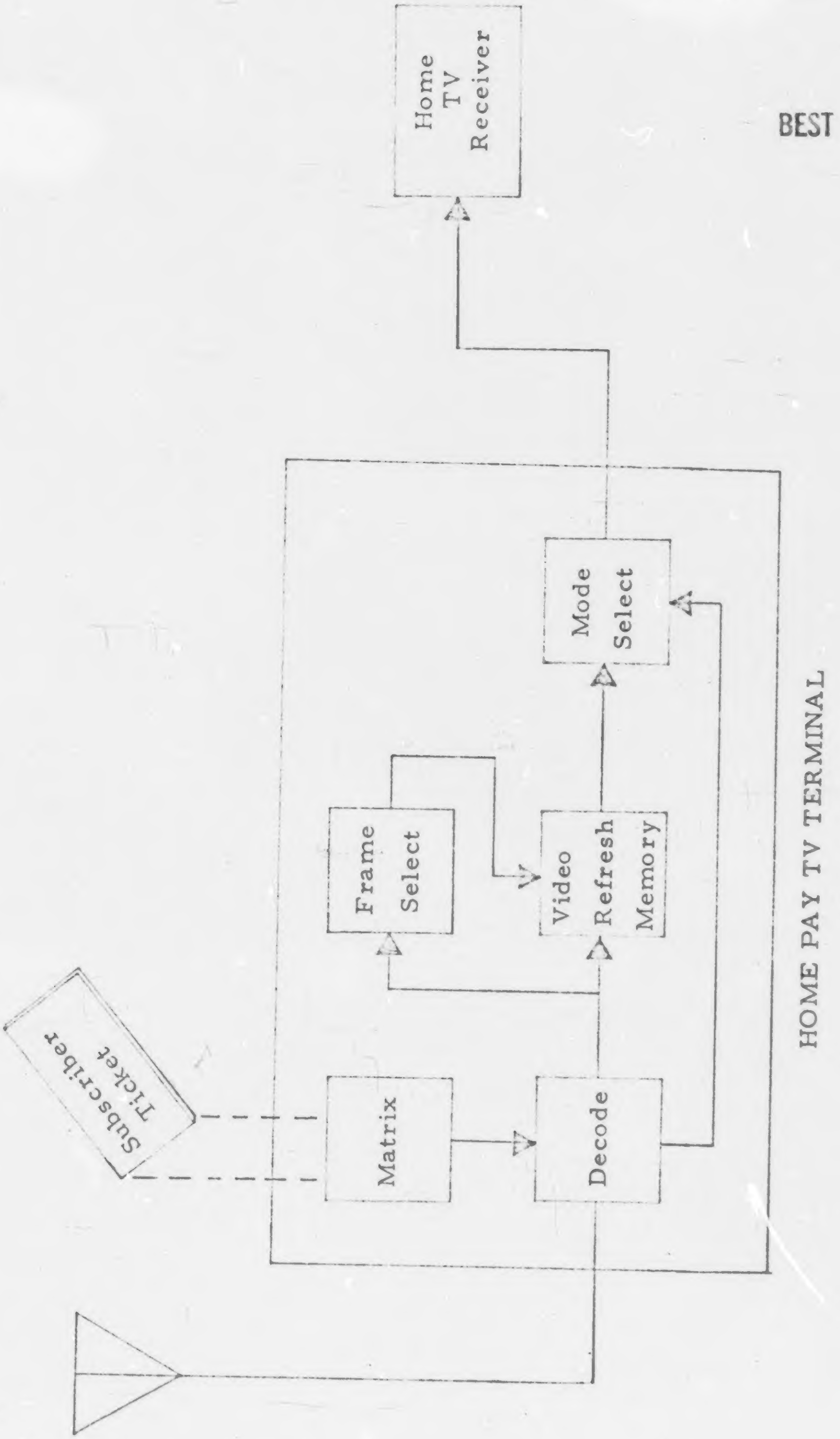
Milwaukee: Applications are in process.

The use of over-the-air Pay TV should be considered in the implementation of ITV because of the revenue Pay TV generates. However, there are drawbacks to Pay TV. The entertainment market will provide the profit and a known market for the Pay TV operator, but only one TV channel within a market area with five or more TV stations presently will qualify under the rules of the FCC. Thus ITV would have to compete against entertainment for that one channel's time. Only one channel severely limits the quantity and diversity of ITV presentations that can be made. The use of multiple OTA Pay TV channels with several ITV channels would require a new, possibly different, and more expensive home terminal. The increased home terminal cost would have to be borne by the ITV Pay TV revenue, and the FCC would also have to allow ITV additional OTA Pay TV channels.

An OTA single frame storage channel could be incorporated as an adjunct to the over-the-air UHF TV. This channel could be encoded and operated on a pay basis similar to conventional OTA Pay TV. ITV information, presentations of coursework provided on a slide by slide or panel by panel technique, would be the bill of fare presented by this channel. The home Pay TV terminal for this type usage would require the addition of a video refresh memory to hold the snatched frame and the frame selection circuitry to snatch the desired frame (see Figure 7-18). The quantity of simultaneous programs on such a channel could easily be up to 300 or more. If this channel were an educational TV channel it would also be carried on the CATV systems in the same area. Special FCC approval would probably be required to operate this type of OTA channel. It is also probable that a special Pay TV terminal design would be required. The techniques, however, are well known and some Pay TV companies, e.g., Telebeam, are already supplying single frame distribution in their cable systems in motels and hotels. They are using a Sony VRM, which costs about $50. For a home terminal this cost is still pretty high, but new techniques or large quantities could bring the VRM costs down.

BEST COPY AVAILABLE

BEST COPY AVAILABLE


Home
TV
Receiver
Mode
Select
Frame
Select
Video
Refresh
Memory
Subscriber
Ticket
Matrix
Decode
HOME PAY TV TERMINAL

UHF TV -- Frame Grabber Channel System

Figure 7-18

There are other drawbacks to this system, e.g., the lack of audio to go with the stored frame. There is only one audio channel in the regular TV channel and we would really like audio with each slide or panel series that could be viewed. There are a number of ways this could be accomplished on cable in the bandwidth available, but on OTA the other bandwidth is allocated. Suppose we digitized the audio and placed it in one of the video frames. We need 19 kilobits/sec. of data for 10 seconds, or 190 kilobits of data. If we take 525 lines per frame we would need 362 bits per line plus the memory to hold 190 kilobits. If we used two frames for audio, then we could still have 100 programs in ten seconds plus ten seconds of audio. We then would only need 95 kilobits of audio per frame, or 182 bits per equivalent line. We could shift this audio information into a memory and then shift it out into a delta demodulator at the rate required by the demodulator, but this approach presents two problems: 1) the memory and 2) the modulation of the transmitter carrier. The second is the easiest to solve, the memory more difficult. The first thought is to use a high density solid state LSI MOS memory (shift register) in a serial in and serial out mode.

The above scheme allows us to stay within the present television bandwidth constraints and still allow multiple channels of audio for the various programming. FDM would also be a way of adding the audio channels for the TV frame storage channel. With 100 to 300 simultaneous programs possible, the additional bandwidth for audio would be a minimum of 300 kHz to 900 kHz, but more likely about double that. The home terminal would be more complicated and involve analog type circuitry.

In the TDM scheme involved above, the digitized audio would be fairly good for voice over the 200 to 3,000 Hz region. A further investigation into the ideas presented above may be of interest to HEW and would provide a more definitive description, costs, and feasibility for implementing the single frame distribution system on an OTA TV channel as well as a means of implementing the definition of and costs for the home terminal.

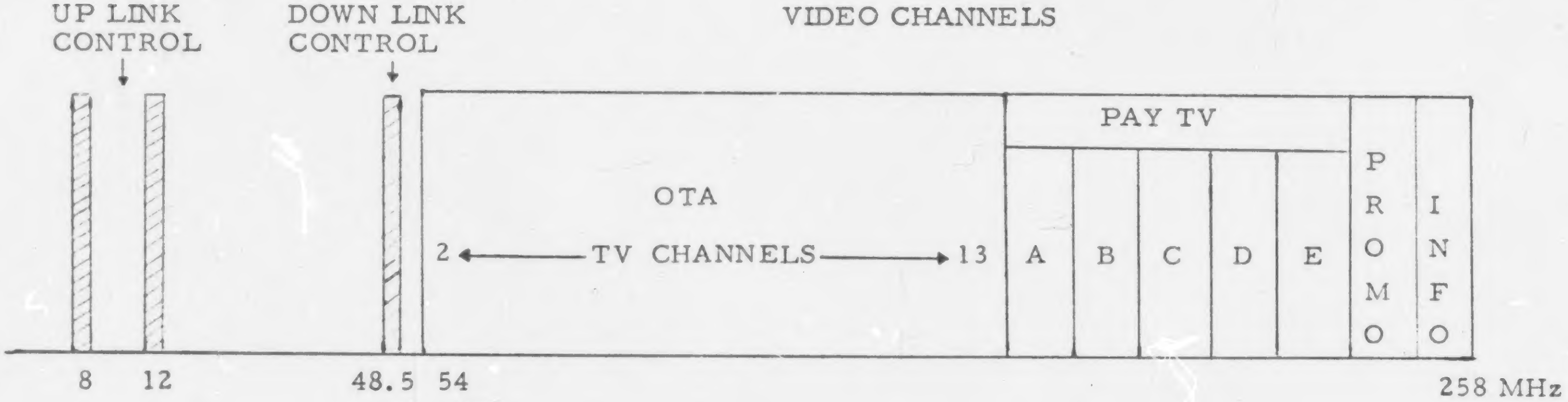
08c

7.3.3.3.2 Cablecasting

Pay TV cablecasting has the potential to play a significant role in the implementation of ITV, since each coaxial cable has the capability of as many as 25 simultaneous channels within the cable spectrum. Further, most CATV operators are installing dual coax cables in their new systems installations. The use of Pay TV on CATV systems is a logical extension of CATV service. Because of the numbers of channels available, ITV has a better chance to get its own dedicated channels. These are essentially private systems serving a concentration of users. Many of the motels/hotels in New York City have Pay TV systems - for example, the Americana Hotel, which has installed Telebeam's system. These systems involve two-way interactive operation which is provided by control wiring, switching, a return channel on the coax, or by a phone call to the hotel desk in some systems. The hotel uses its own internal MATV system for distribution. In addition microwave links (12,2000 to 12,700 MHz band) from a central headend to hotels in the same geographic area and in the same hotel/motel chains are used. Proponents of Pay TV include:

- Computer Television's Computer Cinema
- Philco-Ford's Theatre Vision
- Player's Cinema Systems, Inc.
- Telebeam Paytel
- Previewing Entertainment Corp.
- Motorola
- TransCom Productions

The Telebeam system is a two-way interactive Pay TV system. The system uses the coaxial distribution system to distribute the free over-the-air television channels of 3, 4, 5, 7, 9, and 11 from the MATV (master antenna TV) system. In addition, (See Figure 7-19) it adds seven video channels and two control channels to the coaxial distribution system. A central area provides for the location of the minicomputer and the Sony VTR's. In the room of the user, near the



UP LINK CONTROL
DOWN LINK CONTROL
VIDEO CHANNELS
PAY TV
OTA
2
TV CHANNELS
13
A
B
C
D
E
PROMO
INFO
8
12
48.5
54
258 MHz

Figure 7-19 Cable Spectrum (MHZ)

TV set, an interactive terminal is provided and also an RF unit. The interactive terminal can be used to select the Promo-Channel which provides promotional material on the Pay TV channels, information on the operation of the terminal to receive the various programs, and information that can be called up on the system for theaters, dining, shopping, etc.

Five channels are provided for entertainment Pay TV and include first-run movies, sporting events, etc. These channels the viewer pays to watch on a program basis--that is, he buys the movie he wants to watch. He can view the movie immediately (in progress) or wait until the beginning of the next showing. The last video channel is the information channel. This channel uses a frame snatcher to look at single frames. The user selects the type of information he desires and keys this in by means of the terminal and the single frame is displayed on the TV set until another frame is selected or is cancelled.

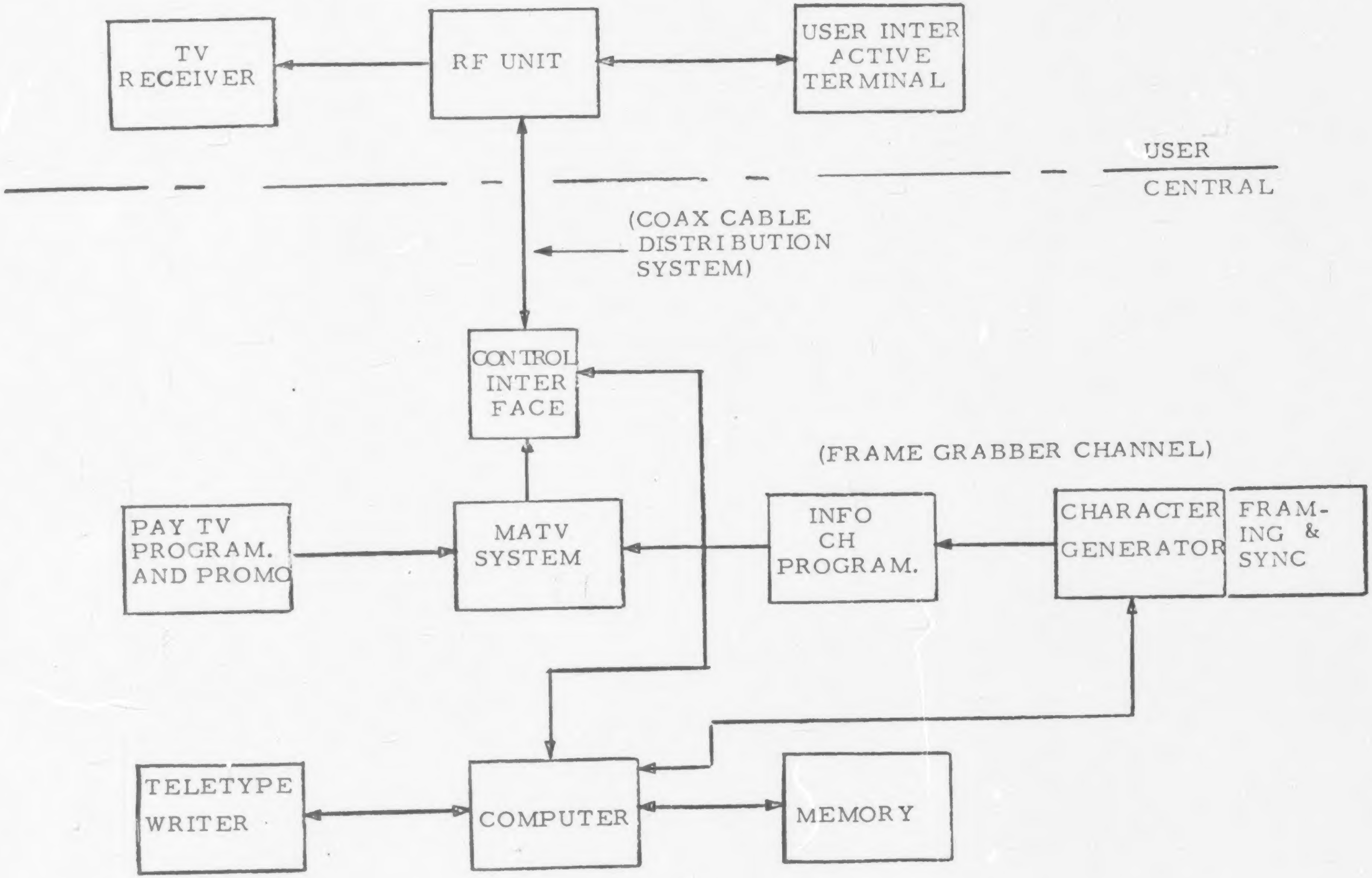
The system operates by adding seven video channels in the cable in addition to those channels with free TV from the MATV system. Below the first TV channel, channel 2, is inserted a 48.5 MHz channel for down-link control from the central control/minicomputer location. This channel polls all the terminals and also sends control information to all units. At the user end, (see Figure 7-20) the control information is received and demodulated by the RF unit. The RF unit will take any one of the seven video channels added and convert them to TV channel six, an unused channel in the New York City area, depending on the control information received on the 48.5 MHz control channel. Also at the user end the user terminal is used to select free OTA TV or the promotional channel (free, paid for by advertisers whose information appears on that channel) or one of the five channels with pay programming. The selection on the terminal by the user is transferred on the 5-8 MHz control channel up to the central control on the coax. The mini-computer selects the control information to be transferred back to the user's unit and takes care of billing. The user's unit can also transmit back information from room sensors such as fire and smoke detection, security information, including room entry, authorized (e.g., maid or room renter) or unauthorized entry, room status, e.g., made-up, not made-up, occupied, etc. The up-link control frequencies are obtained by a digital division of the down-link control frequency from the central. The data rate used is 100 kbps. Two thousand room terminals can be interrogated in less than one second.

When the information channel has been chosen, a down-link control message is sent to the requesting terminal just prior to the frame it is to snatch. The information channel only carries video frames. Since a complete frame is sent 30 times per second, the frame length is 33 ms. However, since a complete TV frame is transmitted as two interlaced fields, double the information can be sent if only a field is snatched. However the resolution and number of lines transmitted is reduced by snatching only a field.

Telebeam is installing systems in low-cost cooperative apartment projects in the New York City area. They believe that as the public starts to accept the Pay TV and security services, and as subscriber revenue is accumulated, it would be a natural extension to add ITV. Most of the development funds for the expansion of these delivery systems came from the private sector. If HEW were to be interested in providing developmental funds for ITV, a much more rapid development of both hardware and software would take place and a cost-effective delivery system would be available for densely-concentrated communities.

7.3.4 Microwave

The systems and equipment referred to in this section are for point-to-point communication utilizing microwaves. (Microwave



TV RECEIVER
RF UNIT
USER INTER ACTIVE TERMINAL
USER
CENTRAL
(COAX CABLE DISTRIBUTION SYSTEM)
CONTROL INTER FACE
(FRAME GRABBER CHANNEL)
PAY TV PROGRAM. AND PROMO
MATV SYSTEM
INFO CH PROGRAM.
CHARACTER GENERATOR
FRAM- ING & SYNC
TELETYPE WRITER
COMPUTER
MEMORY

Figure 7-20 System Block Diagram Telebeam

broadcasting used for ITFS was discussed in the OTA broadcast description and is excluded here.) The extremely small wave length transmission of microwave has some unique properties that can be taken advantage of for point-to-point transmission. The first is the fact that relatively small antennas, three foot parabolic antennas for instance, concentrate the waves into well-formed narrow beams. By collecting most of the energy radiated in the beam, the antennas can provide a higher gain than omni or isotropic antennas. These beams allow essentially line of sight transmission from one point to another.

Microwave interconnects can provide the means of interconnecting headends of CATV systems and/or the relaying of CATV signals to physically separated areas where concentrations of homes are separated from the headend due to the distribution of population in towns or clusters, or where the intervening terrain makes a direct link difficult due to mountains, valleys, rivers, etc. Microwave interconnects can often provide a more economical means of communications than the laying of cable trunks in specific situations. In urban areas where it might be initially both expensive and difficult to dig up city streets to lay cable, microwave offers the CATV operator a very good return on investment in the initial hook-up phase. Therefore, in the layout of a system there is a trade-off between the use of cable and microwave to be considered in the system design and implementation. There are a number of people who supply microwave equipment--for example, the Laser Link Corporation. Their equipment can be procured to transmit 5, 12, or 18 TV channels simultaneously on a link. Repeaters can be added to carry the signal around or over obstacles and to extend the link's overall distance. An illustration of some applications is shown in Figure 7-21.

Microwave transmission of TV signals to cable systems was limited to the LDS or 11 GHz band. However, the FCC has modified

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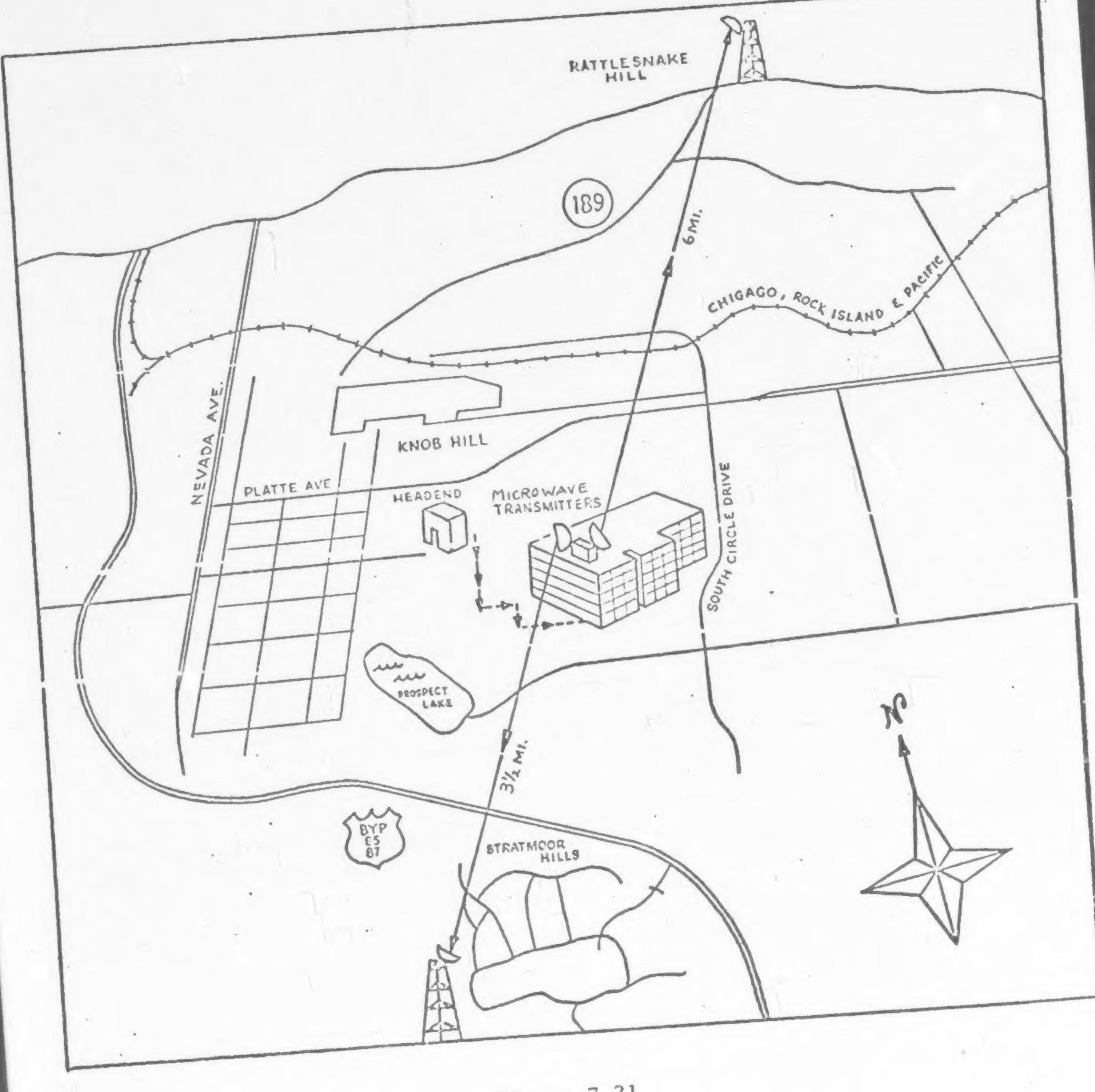

RATTLESNAKE HILL
189
6 MI.
CHICAGO, ROCK ISLAND & PACIFIC
NEVADA AVE.
KNOB HILL
PLATTE AVE
HEADEND
MICROWAVE TRANSMITTERS
SOUTH CIRCLE DRIVE
PROSPECT LAKE
3½ MI.
N
BYP 85 87
STRATMOOR HILLS

Figure 7-21
Microwave Interconnects For a CATV System

Parts 2 and 21 of the rules for licensing common carrier microwave radio stations to relay TV signals to cable systems in order to allow limited use of the 4-6 GHz common carrier bands for the purpose of serving cable TV systems and to eliminate the conditional renewal of these facilities.

In general, the equipment for a microwave link consists of the transmitter, the transmit antenna, and, at the far end of the link, the receiver and its antenna. Additional items are antenna towers and mounts, wave guide and fittings. A repeater may be inserted to extend the link to greater distances over or around obstacles. A single TV channel or many TV channels may be multiplexed onto the transmission. Typical of the Laser Link configuration are 5, 12, or 18 channel equipment. The transmitter power required is dependent on the length of the transmission path, the size (gain) and height above ground of the receive and transmit antennas, the sensitivity of the receiver, the signal to noise ratio desired, and the fading margin chosen. These figures may be obtained from maps of the links involved, curves or calculations of the link parameters, and the use of known equipment parameters. The use of satellites also involves microwave transmissions and reception. Satellite systems are discussed in Section 7.3.5. Microwave transmission is also used for long haul communications by the telephone companies, special common carriers such as MCI and Datran, and private systems such as for the control and supervision of pipelines.

A microwave umbrella can be established using low cost repeaters for TV information. In the following paragraphs a repeater system is discussed which should be of value to future systems. It provides reliability in that signals would not fade due to rain or fog; it also operates at very low levels and can be built at very low cost and used in large quantities in urban areas.

The basic principle of the phase-locked relay system is as follows: each relay unit consists of a phase-locked loop and its major components, i.e., a VCO, a mixer, a receiver and transmitting antenna (which on occasion can be one and the same antenna) and sundry other circuit elements and components. Without modulation present each relay unit would transmit a CW signal. It would also receive one or more CW signals from the other relay units in the system. When receiving given CW signal(s), the relay unit attempts to lock on to that particular frequency and phase and reradiates the same frequency. In effect all relay units in the system try to lock on to a common frequency. Analytic and computer simulation studies indicate that under proper design (when all units are essentially identical in operational characteristics) the system does lock to a common frequency. If one of the units is modulated by an FM signal, all other units will track. Therefore, an FM signal generated at one end will appear (with some time delay) at all other units. It should also be noted that the baseband signal is also available in a phase-locked loop for local distribution.

When used as a local distribution system for TV relaying, the first relay unit receives the FM signal from the control transmitter, locks onto and retransmits it. The demodulated signal is automatically generated as the input to the VCO. This demodulated signal is passed on to a local distribution network which delivers the desired television signal to a customer. As already described, the phase-locked loop, in addition to demodulation, also regenerates the original television signal on the same carrier frequency as the control transmitter. The relay network then retransmits the newly generated television signal to the next relay unit. The second relay unit also receives some signal from the control transmitter. This redundancy is added in because the overall system will continue to function even if relay unit #1 fails. The redundancy also achieves increased overall system bandwidth. Furthermore, an additional relay unit can be introduced in the system without modifying any of the other relay units. They all go in lock step together.

7.3.5 Satellite Systems

The use of domestic satellites in CATV interconnection is an exciting new possibility. The extension of CATV networks through the use of satellite distribution can enable CATV system operators to generate quality programming that could compete with the programming of big TV networks. A satellite enables many CATV systems to gather their resources and enables them to distribute their programs economically. Recent filings by companies before the Federal Communications Commission for commercial domestic satellite systems were required to discuss terms and conditions under which satellite services would be made available for data and computer usage in meeting educational requirements. Of eight applications that were filed, only four responded by spelling out their public service offerings and only one (MCI-Lockheed) explored possible computer usage. Only one proposal (Fairchild-Hiller) contemplates use of frequencies (2.5 GHz) and satellite power levels suitable for use of low-cost earth terminals for interactive communications.

What is needed to fully satisfy instructional requirements is a relatively highpower (55-60 dBW e.i.r.p.) dedicated educational satellite capable of operation with a large number of small earth terminals. However, such a development would require a pooling of a large percentage of educational telecommunications users. Such cooperation presents major political-administrative-organizational problems. Technical problems appear to be solvable. In addition, for distances greater than 70 miles, the economics of satellite-based computer communications with small, display-terminal based interactive interconnections appear to be more attractive than terrestrial-based communications.

Systems have been proposed by Western Union Telegraph Company; Hughes Aircraft Company, and four telephone operation companies of GT&E Service Corporation; by Western Telecommunications, Inc.; by RCA Global Communications, Inc. and RCA Alaska Communications, Inc.; by Communications Satellite Corporation and AT&T as a team; by Comsat separately; by Lockheed MCI Satellite Corporation; and by Fairchild Industries, Incorporated. Table 7-11 provides a description of the number of satellites and their transponder capacity.

The original applications filed by these several companies provide a range of possible services to CATV system operators and a considerable variation in possible business relationships with users. A most interesting application, from the standpoint of the CATV system

TABLE 7-11

SATELLITE PROPOSERS

Proposers	Satellites	Transponders/ Satellite	Transponders
1. Western Union Telegraph Co.	3	12	36
2. Hughes and GTE	2	12	24
3. Western Telecommunications Inc.	2	12	24
4. RCA Globcom and Alascom	3	12	36
5. Comsat and ATT	3	24	72
6. Comsat	3	24	72
7. MCI Lockheed	2	48	96
8. Fairchild Industries	2	120	240
Total	20		600

operator, is that proposed by Hughes. Hughes proposed a system to generate programs and distribute them for a fee via satellite to CATV operators. Hughes presented a fee schedule based on a fixed charge for each subscriber to a CATV system. Quoted fees have ranged from 25 cents per month per subscriber to $2.00 per month per subscriber, depending on the amount of service the CATV operator got from Hughes, and the type of programming.

MCI-Lockheed said it would primarily provide leased telecommunications services. It would provide service for the transmission of CATV programming either on an occasional basis or with a full time dedicated transponder, one TV channel per transponder. Lockheed proposed to establish 15 transmit/receive earth stations at major metropolitan centers which would be program sources, and they also proposed the establishment of receive-only ground stations which could be used for CATV service and either owned by Lockheed or by the CATV system.

Fairchild Industries proposed to provide 24 channels for wide area TV coverage of the 48 contiguous states. Western Union proposed to provide ten full-time channels for video services. The AT&T-Comsat proposal is for a system dedicated primarily to expanding the existing services that AT&T now provides. It would involve three satellites to be put up and operated by Comsat, and five ground stations. It makes no specific provision for CATV program distribution or for distribution to receive only earth stations. AT&T does propose to provide adequate circuit capacity in the system for program distribution, but it would have to be leased to another operator to provide for CATV use.

None of these applications, with the possible exception of Fairchild Industries, offers the hope of a reasonably economical system for the distribution of television programs to CATV headends. Fairchild has quoted prices of from $234,000 to about $360,000 per year per channel, and the rest of the applicants have proposed prices from $75,000 to $125,000 per month. Most of them contemplate a channel in the present 4-6 giga-hertz bands, which will require earth stations estimated to cost $75,000 to $100,000 each. The total of the applications would provide about 600 transponders in space and each transponder is capable of carrying a television program in one direction and a much larger number of narrow band data channels. So there is a real question as to whether all of these would provide economically viable systems.

The satellite communication system consists of two separated subsystems, the earth segment and the space segment. For effective system operation both subsystems must be appropriately integrated. Since, in general, the satellite communication system is not isolated, the earth segment must also be integrated and interfaced with a terrestrial communication interconnecting system. For ITV the regional centers form the interface to the earth segment (ground stations). The earth segment consists of the following structures:

a. an aggregation of message originators capable of transmitting to and being received by the space segment;

b. an aggregation of message receivers capable of receiving from the space segment;

c. a telemetry tracking and control (TTC) system which commands, controls and monitors the space segment;

d. the launching vehicle.

The space segment is a distributed set of operating satellites along the appropriate geostationary orbital arc which provides appropriate communications connectivity between and among the message origination and receiving aggregations of the earth segment. It operates essentially by changing the direction of the up-link signal to an appropriate down-link signal, although a space-to-space link among members of the satellite set is technically possible.

This segment includes also everything required in space to support the communications equipment operating from the satellites. Included in the space segment are the in-orbit satellite spares which are a nonoperating distributed set of geostationary satellites.

Although the space segment is quite complex and expensive, the overall communications system is simple in principle, as is shown in Figure 7-22.

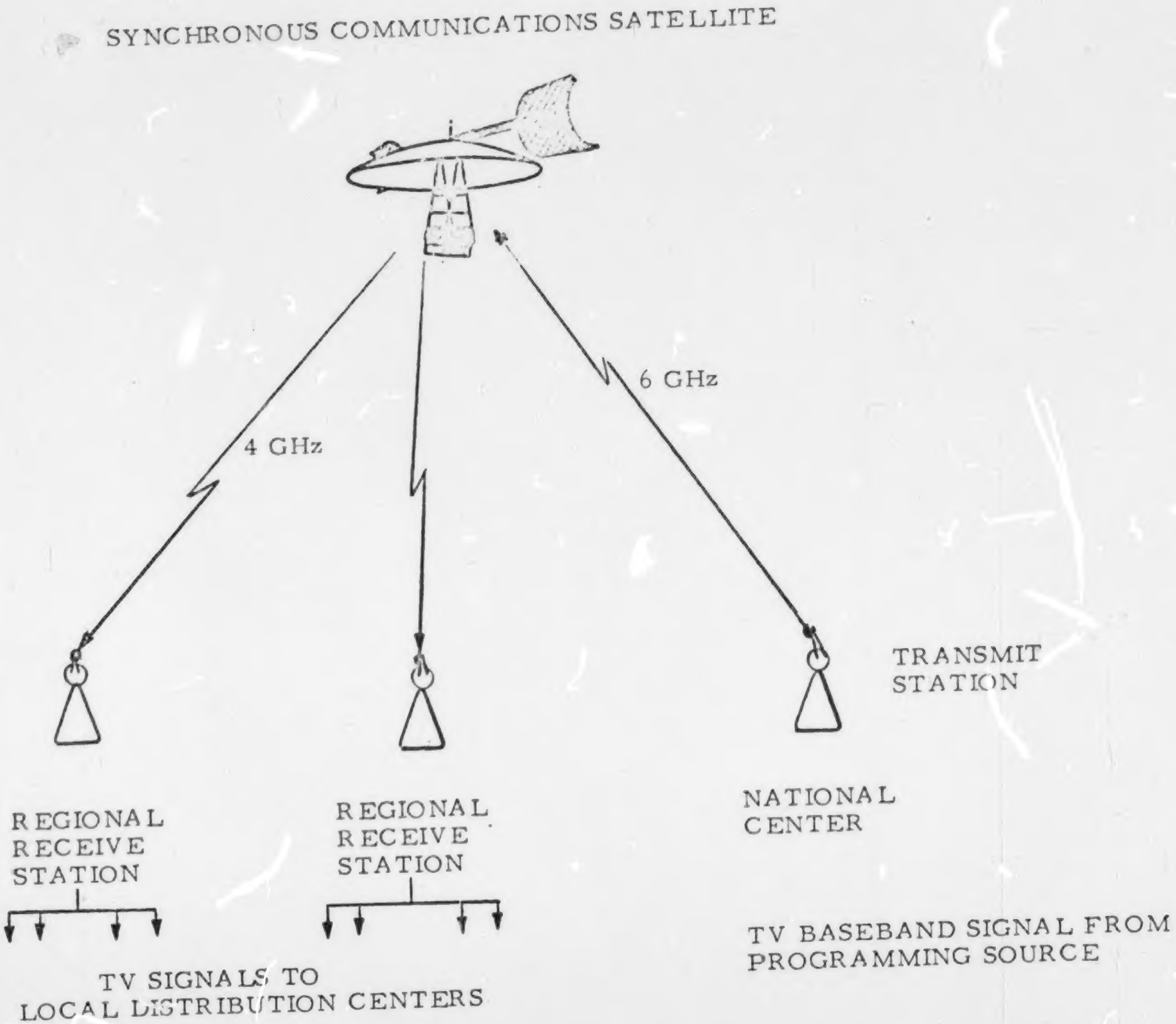
The TV baseband signal to be transmitted is used to modulate the 6 GHz uplink signal from a national center-transmit earth station. The communications satellite, in synchronous orbit, approximately 22,300 miles above the equator, receives the 6 GHz signal. In the satellite, the signal is translated to 4 GHz, amplified, and is beamed to multiple regional receive stations. The received signals are then converted to VHF TV signals and may be relayed to various Local DistributionCenters either by cable or by terrestrial microwave.

The general functional operation of the Satellite System is subdivided as follows.

a) The message originating aggregations organize and control the up-link brandwidth time utilization to assure message receipt at the space segment in appropriate time order, with the correct power levels for message relay and appropriate message receipt by the message receiving aggregations. The control may require therefore a signalling procedure.

b) The space segment transforms the received signal, with amplification or regeneration, so that its spectral, magnitude and directional characteristics are appropriate to the ground receiving aggregation or for space relay depending on the control procedure.

c) The TTC system maintains the space segment in the appropriate attitude, space position, with stabilization required for the connectivities, assuring continuity in the operations by replacement or changeover if the operating system should fail.


SYNCHRONOUS COMMUNICATIONS SATELLITE
6 GHz
4 GHz
TRANSMIT STATION
REGIONAL RECEIVE STATION
REGIONAL RECEIVE STATION
NATIONAL CENTER
TV BASEBAND SIGNAL FROM PROGRAMMING SOURCE
TV SIGNALS TO LOCAL DISTRIBUTION CENTERS

ITV Satellite Communications System

Figure 7-22

In 1974/5, the National Aeronautics and Space Administration (NASA) and the Health, Education and Welfare Department (HEW) plan to conduct experiments involving video transmission via satellite to schools and institutions in the Rocky Mountain region. NASA is to provide the satellite (ATS/F) and HEW is to furnish both the programming material and the small earth stations. NASA will transmit programming material devised by the Department of Health, Education and Welfare in conjunction with the Corporation for Public Broadcasting. The NASA earth station at Rosman, N. C., will transmit these programs to the ATS/F satellite (to be launched in the Spring of 1974), which will relay the signals to some 500 small earth stations in the Rocky Mountain region. The small earth stations will be based on design models developed by NASA.

The ATS/F satellite measures about 52' between the tips of its solar panels; has an antenna which unfurls in space to a diameter of 30', a design life of two years, 500 watts of dc power at end-of-life and weighs 3000 pounds in orbit. The satellite radiates 15 watts of RF power (in the 2.5 to 2.69 GHz band) to provide one program (video plus up to four audio) channel in each of two beams. The beams measure 360 miles in the east-west direction and 450-500 miles in the north-south direction.

The small earth stations used to receive these programs will have 7' antennas and the manufacturer's cost is said by NASA personnel to be around $400 to $500 per station. Since the remote television earth station in the TELESAT System was about two orders of magnitude more costly, it might seem to some that this experiment is likely to usher in the age of truly inexpensive satellite telecommunications. A video signal to noise ratio of 47 db (CCIR weighted) will be provided with a carrier to noise ratio of 15 db. Two-way communication can be provided in the experiment.

The technical and economic factors that bear on cost-effective satellite system designs will be developed subsequently, but it might be useful to look now at one of these factors in the ATS/F - Rocky Mountain States experiment. It should be kept in mind that no satellite system can be designed to provide maximum flexibility and capacity with minimum complexity and cost, although any system can be optimized with respect to these criteria. Any satellite system which emerges from the design process is the result of a great many compromises, or trade-offs, between existing component performance capability, the confidence of achieving improvements in performance, the degree of added complexity required to achieve the added performance, the cost of the increased performance and the value of this increased performance in terms either of an improved system or of relaxed performance requirements in other components.

In the ATS/F experiment, for example, the concentration of spacecraft power into a relatively small area permits highly effective radiated power levels and, in turn, allows the use of low performance/ low cost earth stations. An ATS/F beam covers approximately 170,000 square miles and a simple calculation shows that more than 20 such beams would be required to cover the United States. If we assume that a domestic satellite system must serve all of the continental United States, then it is entirely possible that lower total system costs could result from the use of a larger coverage area in the spacecraft beam and higher performance earth stations.

Direct to home satellite broadcasting systems are not likely to be introduced in the United States in the near future. Satellite systems can, however, provide economical video signal distribution to CATV headends and be distributed to home via this method. It is felt that despite potential interference from terrestrial microwave stations, most CATV satellite stations can be located close to the headend system. In this case the audio and video signals are processed by cable system modulation and enter the system as any conventional VHF TV signal.

The ATS/F (applications technology satellite F) experiment in the Rocky Mountains is part of NASA's general policy of making available satellite capacity to interested users: to provide them with experience in satellite communications operations and to give them an opportunity to experiment generally with the kinds of things that this technology helps to do well. The burden of proposing sensible experiments, of developing and supporting the ground system and of operating the experiment, rests with the user.

7.3.6 Home Delivery Systems - Video Tapes and Video Disc

Video tape and video disc represent two ways of recording television programming. Tape is here today and is being used extensively. Disc will be here tomorrow. They represent a package, either of which could be distributed by non-electronic means such as by distributors. They can be mailed, hand carried or shipped in almost any manner, singly or by the gross. With the appropriate players they can be used for viewing on the home TV receiver or for projection on screens by TV projection systems.

7.3.6.1 Video Tape

The use of wideband magnetic tape recorders and reproducers for picture and sound has to a great degree supplanted the use of film. One of the advantages of tape over film is that there is no processing required of the tape and it can be replayed immediately. Generally, broadcast quality TV programming is quadraplex recorded on 2" wide tape.

The programming already available on film can be placed on tape by the use of Telecine units fed into a master video tape recorder which creates a master two inch tape using quadrature recording in a helical scan format, and then the master is used as a duplicating system to create as many video cassettes or cartridges of the program material as is desired.

Video tape cartridge systems are also available with a 1" Video Cartridge Recorder (VCR) and the players are made by International Video Corporation (IVC). The cartridge consists of a plastic enclosure which houses the standard 8" tape reel. There are currently over 11,000 of the reel to reel VTR's already in the field.

Kodak is coming out in early 1974 with a Cassette-Loading Super 8 Videoplayer VP-1 as a means for originating film programs. The Super 8 Cassette Videoplayer generates a signal to produce a color picture on a home TV set. With tape you are limited to an electronic display. With the introduction of the Videoplayer, Super 8 film becomes a medium which allows the communicator to use a conventional screen when it is desirable or a videofilm cassette type display on a TV monitor. The same film in the same cartridge can be used to do either or both.

With more and more material being directly recorded on video tape and the cost of the video cassette player being just under a thousand dollars, it is expected that the video cassette player will begin to supplement the use of 16 mm film in the schools. Videotape cassette players are represented by the Sony U-Matic VP 1000. This player takes the standard 3/4" video cassette with playing times of up to one hour per cassette. The tape used is 3/4" chromium dioxide high energy tape. Because of price, picture stability, and high resolution color or monochrome pictures, this player is used by many CATV operators and Pay TV operators. The player also has dual audio tracks for presenting stereo sound with the video picture. The VP 1200 is a modification to the VP 1000 for those systems desiring automated player operation of single or multiple players. Output of the players can be played through the conventional TV receiver or be fed to conventional CCTV systems and video systems through direct video and audio outputs. Central Video, a new venture in the TV field, provides program material from films replicated on 3/4" tape for CATV and Pay TV users. Sony offers a large selection of Videoplay programs in their catalog of about 8,000 subjects for lease or sale using the U-Matic 3/4" video tape cassette.

7.3.6.2 Video Disc

Video disc offers one of the least expensive means of delivery of programming directly to the consumer. The development of the disc to a great extent is being aimed at the home market; thus ITV discs may ride piggy-back on the entertainment TV disc. The disc player pricing objectives are low in cost, in the range of $140 to $500. Player tapes will include single disc players and automatic changer disc players. The price difference between players, automatic and manual, is stated as about $100. According to the manufacturer's schedule, these systems should be ready for marketing in 1975.

If the facility to make the disc is provided by the entertainment market, ITV then can assume the costs of making a master and the re-production from the master. Material costs for the disc are low, in the order of 40¢ for both the material and pressing. The major cost will be the programming software. Again, the availability of programming material will be vital to the use of video discs for ITV. Present U.S. video disc manufacturers say they will use movie film libraries for their first productions. New programming will come as the industry grows.

There are several different scanning techniques that a video disc player may have. These scan techniques of the high-density storage disc can include electrical, optical or mechanical means. The factors to be considered are:

- The cost for the scanning method should be in proportion to that of the disc and the playback equipment.
- The scanning method should make the system usable in as many applications as possible.
- The method should be as nearly immune to obsolescence as possible.

The different scanning techniques used by particular video disc players are as follows:

- The Telefunken-Decca (Teldec) system will be introduced this fall when production begins on the PAL playback unit priced at $450. The video disc will be priced between $4 and $10. The scan method used by Teldec is a pressure contact with the disc using a diamond tipped piezoelectric transducer.

- The N. V. Phillip's disc is optically scanned by a helium-neon laser in its video disc player (VLP). Introduction of these players is planned for 1975 at a price comparable to a color TV set.
- The French Thompson-CSF does not foresee a worthwhile video disc market in France for another ten years. The company has, however, indicated a choice for an optical-laser reader.
- RCA, which is developing an electrostatic, capacitive discharge scanned disc system, is expected to have models available in 1975.

In the making of the master from which discs are pressed, the images and sound may be recorded by laser or electron beams or by a conventional cutting process. Teldec presently prefers a conventional cutting process.

Irregularities which may occur in disc rotation in the player can cause slight variations in the scanned line frequency. There are two means of preventing the variations from affecting the picture. The first method is to use a short time constant in the horizontal fly-wheel circuit of the color TV receiver. Most Japanese receivers have a sufficiently short time constant. However the U. S. and European sets often have too long a time constant. Thus, for the American market an electronic balancing circuit based on a controllable delay in the playback unit will probably be required.

7.3.7 PLATO (Programmed Logic for Automatic Teaching Operations)

The PLATO system is being developed by the University of Illinois. A two year demonstration of PLATO and TICCIT is being supported by NSF. The demonstrations of these systems are to be independently evaluated by the Educational Testing Service of Princeton, N. J. under a separate contract. PLATO, in contrast to TICCIT, uses a large sophisticated computer in a centralized facility that will serve many schools. Much of its hardware, including a new visual display, has been developed especially for CAI. The student terminals in the Plato system are perhaps the most sophisticated devices ever developed for communicating with a computer; not surprisingly, they are also its most expensive component. The terminals consist of a plasma display panel on which visual information is shown, its associated electronics, and its connections to a telephone line, a keyboard, a random-access slide projector, and various accessories, including a random-access audio device that can both play and record. It has a infrared sensor system that responds to the touch of a finger on any part of the visual display.

The plasma panel, unlike a television tube, can display graphic information permanently without auxiliary storage equipment. It is inherently a simple device, consisting of thin, flat, glass sheets in which two fine-wire grids are embedded. A gas contained between the sheets is ionized when an initial voltage is applied to selected points of the grid, and the ionization is sustained by a weaker alternating voltage applied to the entire grid. Since graphic information can be specified point by point or line by line for the entire 512 by 512 grid, the system provides extremely sharp images and can utilize virtually any type of characters. The panel is transparent, so that color slides can be superimposed on information generated either by the computer or by the student; motion pictures can also be shown on the panel but have not normally been included in PLATO courses.

The terminals are linked to the computer over ordinary phone lines. They provide elaborate graphical displays; they can write at the rate of 180 characters per second, and the computer responds to a terminal within 0.1 second. For remote terminals, the signals for as many as a thousand terminals can be transmitted through a single educational television channel at a great reduction in cost.
The PLATO system is based on a large computer -- the Control Data Corporation (CDC)6400 - - the system is intended to have four central processors and to serve, at any one time, as many as 4,000 student terminals located anywhere within an 800 mile range of the computer. The PLATO system is thus one of the most ambitious

time-sharing systems ever attempted. Much of the hardware, a new programming language adapted for teaching, and economical new techniques for linking remote terminals to the central computer were designed specifically for educational use; the designs were based on substantial experience with earlier versions of PLATO, including more than 100,000 hours of CAI instruction in grade schools, community colleges, and university classrooms.

The method of developing educational materials for use with the TICCIT and PLATO systems differs greatly. The TICCIT program has adopted a formalized method of developing CAI "courseware" through the collaborative efforts of teams of programmers, educational psychologists, and specialists in the subject of the course. The PLATO program espouses the more ad hoc approach of letting teachers design their own courses with the aid, if necessary, of the PLATO staff. For authoring new courses, a programming language (TUTOR) based on English grammar and syntax is designed for use by teachers with no knowledge of computers. Some 200 such teachers of varying backgrounds have created courses with TUTOR on earlier versions of PLATO. TUTOR includes special methods of generating graphical displays, of preparing dialogues between the student and the lesson, and of judging student replies.

The PLATO system makes use of unique storage features of CDC computers which allow very rapid access to blocks of stored information, so that no use is made of slower, mechanically driven disk memories during a lesson. The status of all students who are "on line" as well as the materials for several hundred different lessons are thus stored directly in the computer. Only one user is served at a given moment, however, and that service is completed before the next request is handled. The result is that almost the entire computational power of the computer is available to the student. To preserve efficiency, the PLATO programs avoid symbol manipulation, and to conserve memory they try to generate desired information by computation rather than by storing large amounts of material.

7.3.8 Advanced Broadband Information System

So far a number of delivery systems have been discussed that could be employed for the delivery and distribution of ITV programming, but all have certain limitations to them as far as providing ITV to the home and schools. What should a new system provide? It should be capable of providing revenue, allowing one-way and interactive interface to the user, and have the available spectrum to allow multiple ITV channels so that a wide variety of programming could reach the maximum number of users. It should also be able to use ITV information from its many sources; and last but not least, it should be an economically viable system. A system that can provide all of these objectives is described below. This system, which can be achieved in the near future, is capable of evolutionary development and utilizes electronic means of delivery. It will undoubtedly coexist with other forms of delivery we have already described.

7.3.8.1 Delivery System Model

The advanced delivery system model for ITV was represented earlier in simplified form in Figure 7-3. The implementation of the delivery system represented by this figure can be evolutionary, occurring in stages or levels. In the process of achieving the full implementation of ITV there can exist throughout the country simultaneously various levels of implementation, with not all areas necessarily at a common level.

The system consists of the unit or terminal in the home or school classroom; the transmission media, cable, microwave, laser or combination of these to provide the interconnection to the local center; the local center consisting of the CATV headend, local program origination facilities, computer processing facilities to support ITV and Pay TV requirements; and external information sources. The external sources of programming and control are via the transmission media of microwave, cable, etc. to other CATV systems or regional centers. The regional center allows the sharing of facilities and programming sources by those systems it serves. Programming insertion from regional sources can be originated there. The program sources can include an

ITV library or program bank, computer controlled for automatic access and retrieval. In addition the regional center allows the sharing of a satellite ground facility for programming interchange with other regional centers via satellite and/or the interconnection to a National Curricula source of programming, including special events, live broadcast and an extensive library of program material. The regional center allows the sharing of computer facilities for computer aided instruction. Large and affluent CATV systems may also have their own satellite capability for interconnection to regional centers and/or the national center. As a minimum for ITV the advanced delivery system will deliver to the home the following services:

Frame storage interactive channels
Information storage and retrieval channels
ITV video channels
Computer assisted instruction channels
Individual ITV program selection.

These services are described as follows.

- Frame Storage Channels

One of the TV channels will be dedicated to a frame storage (frame grabber) system in which the dispensed information is composed of visual panels or pictures. The basic system timing will be derived from the vertical sync which is used for frame counting. For example, implementation could use a major grouping of 384 frames with a cyclic period of 12.8 seconds. The major is then divided into three minor groups of 128 frames each, with a period of 4.3 seconds. The first 28 frames of every minor contains information of general interest to the public. The first frame (#0) presents a table of contents and list. The remaining 100 frames in the minor are reserved and assigned to individual subscribers in consecutive order, as shown in Figure 7-23. More minor groups may be added in time, with no modification of the home terminal except at the expense of increasing the time of the major group cycle.

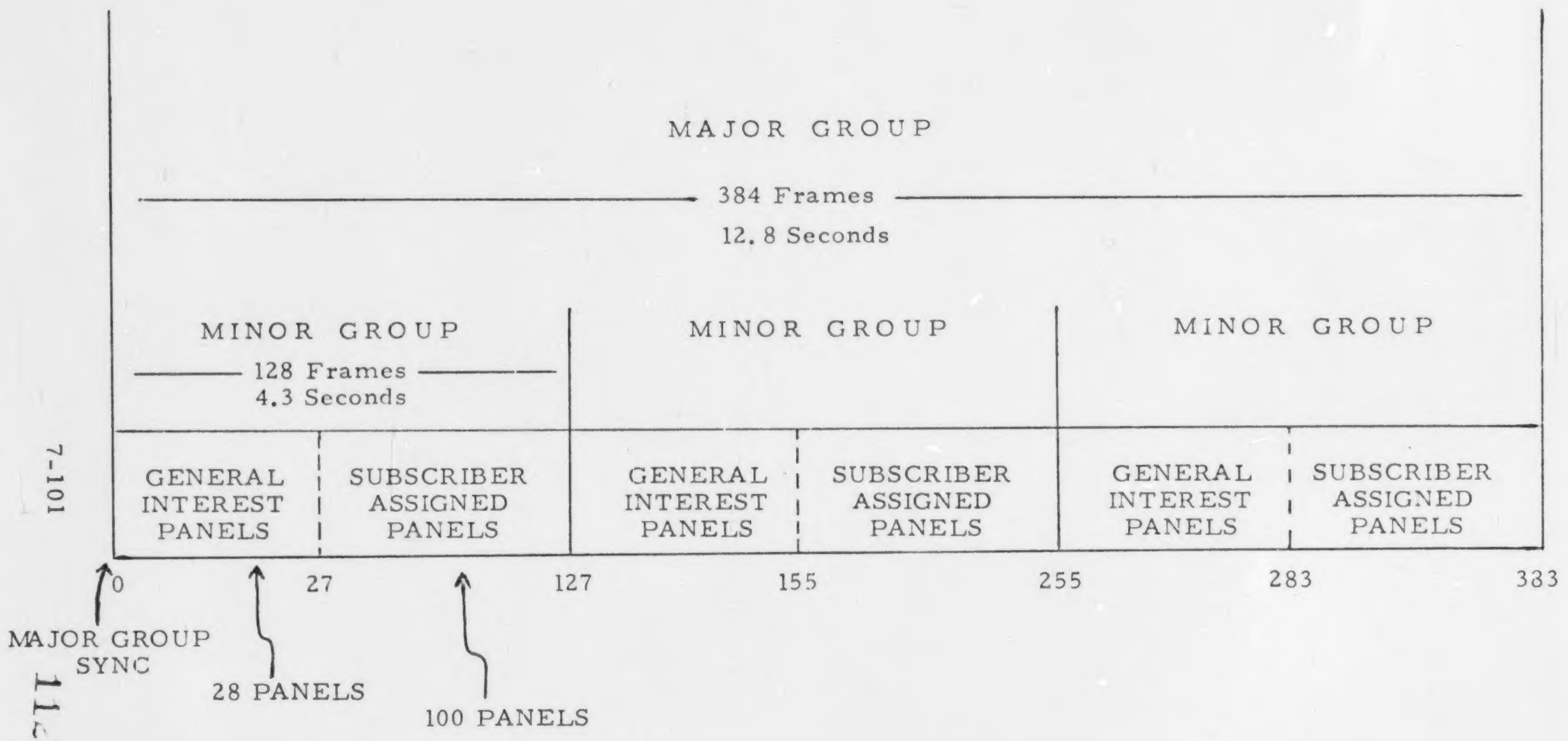

MAJOR GROUP
384 Frames
12. 8 Seconds
MINOR GROUP
128 Frames
4.3 Seconds
MINOR GROUP
MINOR GROUP
GENERAL INTEREST PANELS
SUBSCRIBER ASSIGNED PANELS
GENERAL INTEREST PANELS
SUBSCRIBER ASSIGNED PANELS
GENERAL INTEREST PANELS
SUBSCRIBER ASSIGNED PANELS
0
27
127
155
255
283
383
MAJOR GROUP SYNC
28 PANELS
100 PANELS

Figure 7-23 System Timing

Frame selection is based on the time position of the desired frame within the major group, the start of which is identified by a group sync signal. For a small scale system, it is not necessary to insert digitally-encoded addresses in the video frames. As the system enlarges, the addressing function can readily be added at any time. Synchronization of the major group is achieved by detecting the absence of a number of horizontal sync pulses which are purposely deleted in the vertical blanking interval in the first half frame of the first frame (#0). The number of deleted horizontal sync pulses may range from 3 to 10 but should be chosen so as not to cause the TV receiver horizontal oscillator to drift out of sync and cause a severe transient when the sync pulses return.

- Information Storage and Retrieval Channel

This channel is a frame storage channel whose use and purpose is dedicated to retrieval of information. It can serve a library type function for obtaining reference information and data. Random access to this channel will be provided so as to accommodate the maximum number of users on a statistical basis. A busy signal will be returned to the requestor of service if all frames are being utilized or equipment at the central bank is busy and can't handle the request within 15 seconds.

- ITV Video Channels

ITV programming will be provided on the video channels allocated to ITV. Selection will be as for Pay TV. Programming will be in color or black and white, depending on the program material. Implementation of a separate cable for ITV will allow the showing of 20 to 25 channels of ITV programs simultaneously in a one-way mode.

- Computer Aided Instruction

Computer aided instructional programming will be provided via the frame storage channels. Expansion of computer aided instruction programming could grow to a dedicated channel for this mode of operation and programming.

- Individual ITV Program Selection

The advanced broadband information system should provide dedicated channels for ITV programming in sufficient quantity (10 to 15 channels) to allow a wide variety of simultaneous programming. Further, these channels shall be provided in a manner similar to Pay TV, so that billing for programs received can be made and usage of ITV programming determined. Off hour programming should be provided to schools and institutions for unattended automatic recording and subsequent use during school hours for classes and special instruction. A variety of ITV programming should be selectable on individual demand by the home user at the time desired. Programming variety should include interactive as well as one-way presentations. Other ITV programming should be on a scheduled basis and the channel selected on the basis of schedule programming to be received.

7.3.8.2 Delivery System Elements

The elements of the system are shown in Table 7-12, with the functions and objectives listed under each major element or sub-system. There are several ways of describing the system, such as from the top, which is the national facility, to the unit(s) in the home, which is the bottom element of the system. Here we are going to go from the unit in the home to the national facility or center. Each element builds onto what has gone on below it.

1. The CATV Home Receiver

The existing TV receiver has a number of disadvantages in its use on CATV, and its replacement by a receiver designed specifically for CATV will come about slowly but inevitably as CATV enters more and more communities and homes. A number of TV receiver manufacturers have recognized the need for a receiver for use with cable and having better shielding from OTA signals, tighter cable coupling and tuning for 24 channels.

Functional Objectives

The home receiver should in the future provide a means whereby the subscriber can easily interact

TABLE 7-12

BROADBAND INFORMATION

BEST COPY AVAILABLE

A. Home Unit

- 1) TV set with no extra boxes or appliques required. Capable of being modularly expanded to provide the full service of:

    CATV free channels
    Pay TV free and pay channels
    Frame storage (grabbed) channels
    Minimum of forty TV channels
    Interactive capability for requesting individualized programs and services, e.g., message entry and response
    Remotable controls

    Accessories available to include:

    Video tape player
    Video disc player
    Printer for hard copy facsimiles

B. Local Center (Headend)

- 1) Interconnect

    Consumers - wideband Dual or Triple Coaxial Cables with two-way implementation, home to local center (headend)
    Regional Centers - wideband cables, microwave, lasers or common carrier. Forty video channel plus two TV channel bandwidths for interactive data, control, requests monitoring, etc.
    National Center(s)
        Satellite to local ground station
        Non-electronic interconnect - mails, etc.
        Microwave - by special common carriers

- 2) Local Origination Studio(s)

    Interconnect to headend
        --Coaxial Cable, microwave or laser to headend
    Studio(s)
        --Facilities for local program origination (as required by FCC)
        --Personnel - AV technician, director
        --Other - studios in school systems, etc.
        --Preparation of programs for video tapes and live broadcasts
        --Training in AV techniques
- 3) Reception of over-the-air broadcasts

- 4) Pay TV operation/public service operations

- 5) Multiplexing 20-25 TV channels on each cable (down link)

- 6) System Controller-Computer, memory and computer programs two-way interactive TV, frame grabber information, billing and accounting

C. Regional Centers

- 1) Interconnect to local headends

- 2) Interconnect to national center(s)
    --Satellite Ground Station (two-way communication for some centers - receive only for others)

- 3) Regional Program Library

- 4) Regional Origination Studio (limited to large regional centers)

- 5) Program Interchange
    --National-Regional
    --Regional-Local
    --Local-Local (via regional centers)

D. National Center(s)

- 1) Interconnect to Regional Centers
    --Via Satellite
    --Mail
    --Special Common Carrier ITV and Educational

- 2) Interconnect to national program sources
    --Microwave
    --Cable

- 3) Interconnect to Local Centers
    --Receive only ground stations for satellite link
    --Cable or microwave to local centers vicinity of national center

- 4) National Program Administration

- 5) National Program Library or Libraries

- 6) National Origination Studio
    --Live Programs
    --Program recording/taping

with the central information center of the broadband information system, including simple interactions as well as interactions involving frequent and extensive exchange of interaction between man and machine. In addition to the standard video and audio outputs of present day use receivers, paper copy will also be provided, as well as the capability for audio and video inputs. The home receiver should initially evolve by providing the following features.

a) It should provide internally encoded digital data to be capable of being polled by the computer and the communications system. Digitized output data providing the following is needed:

  --Subscriber address
  --TV set on-off control status
  --Channel being viewed (Pay TV application) monitoring capacity up to a minimum of 24 CATV video channels
  --TV set fault location (leasing and repair service).

b) Interfaces have to be defined which will enable the reception of externally encoded digital data such as:

  --Utility meter readings
  --Digital alarm sensor data
  --Inputs from an opinion monitor (simple 4 and 8 button keyboards).

c) The subscriber terminal serves as an interface between the distribution system and special subscriber sensing and data collection devices. The communication requirements of ITV and household information services are provided by the CATV distribution system.

d) The provision of data inputs by a low cost keyboard system which can encode digital signals for requesting video data, ITV programs, Pay TV, and ASCII code transmissions. These terminal devices will be incrementally expandable, starting with a simple (e.g., three to five button) selector/response input device and evolving towards full keyboards.

e) Through the use of the keyboard system, a code selection mechanism will be provided for receiving continuous broadcast messages. The user would select by a code the particular panel of information he desires from a stream of information being broadcasted.

f) Through the use of the keyboard system, request codes can be initiated by the consumer which would order the broadcast of a specific prepared piece of information.

g) Through the use of the keyboard system, the terminal will evolve into a transactional interactive system that allows for shopping, banking, ITV coursework, etc.

h) The decisions to be programmed by the advanced keyboard terminal can include the options for viewing immediately, playing back the picture later at the user's convenience, making a hard copy print or having the field automatically erased upon the receipt of another television field.

i) To implement these options an Information Storage and Retrieval system (ISAR) will be used at the central system to provide individually addressed video frames; then the video receiving system of the home terminal has to decode the address of the frame. If the message is not for this particular terminal, the decoder will keep its gates shut to the cable TV signals. If the address is correct, the decoder will open its gates and enable the cable television signals to go into a frame storage system.

j) The video refresh memory used for the frame storage option should be able to make a soft-copy display of video frames. Through the use of a facsimile ink-drop printer coupled to the soft-copy frame freeze circuitry, a printing service may be provided for the home.

k) By using storage tubes or solid state devices, a multiple storage system configured for the receiving system should be provided. This should be responsive to the following needs:

--Data transmission (ASCII-Code)
--Soft copy display
--Printing size options
--Tandem arrangements for dual frame storage
--Video recording - linear storage.

l) The video receiving system should be able to handle increasing numbers of channels without direct or adjacent channel interference.

m) The design of the home receiving system in the modular architecture should allow for the economical time sharing of storage, digital communications, and r-f functions.

Future Accessory Objectives

Through the advanced development of the associated accessories, it is possible to meet the following requirements for future ITV and household information services.

a) The keyboards and printers discussed previously.

b) A card verification system. This allows the user to have a specific identification for authentication purposes such as billing services or when he uses another home terminal. The card technique simplifies the need for scramblers or crypto devices in the home.

c) A data base option to be used in the home in the form of videotape or cassettes which could provide software for EDP use, or for use in video recording and playback options.

d) Interfaces for standard TV cameras if video interaction is required.

e) A digital message entry device (DMED) capable of providing all home information services through a remote control unit. This will also include AM-FM, phonograph, video disc or tape player controls.

f) Pay TV channels if they are pre-assigned may require the subscriber to insert a key into the Pay TV control slot in the turner assembly. Positive activation of the key device prevents inadvertent Pay TV channel selection and electronically instructs the computer (system controller) for billing.

g) A hierarchy of interaction terminals for special uses, such as an alarm and telemetering terminal.

2. CATV Distribution System

The dual or multi-cable system provides the basis for an evolutionary expandable system growth. This includes the growth anticipated in entertainment programs as well as in future interactive services. It also takes into account the evolution and growth expected in hardware at the broadcasting station as well as at the home.

A dual cable distribution system utilizing 12 channels per cable allows for a conservatively rated system within today's technology constraints. The retrofit of amplifiers will provide the performance expected in the late 70's and 80's. The basic dual cable systems will provide initially and for maybe the life of the system, a high quality 24 channel video reception. When the components are available it will definitely provide much greater capability than any system initially installed as a single cable system.

Functional Objectives

The following technical and performance objectives are based on providing a conservatively rated, expandable system minimized for cost and for present use by the consumer as his needs for future services are accepted. These objectives will require minimum increases in cost to the basic physical distribution system once installed. Any distribution system selected should include:

a) The ability to increase the number of channels incrementally through a system as channel allocations are filled with identified and acceptable consumer and public services.

b) The ability to provide high wuality performance, through conservatively rating the system, until the need and state-of-the-art has progressed. Example: A twelve channel initial allocation per cable is a conservative rating on a distribution system, although current technology programs may allow growth to 24 channels per single cable in 1975.

c) To allow growth from 12 to 24 to 48 channels per system over a 5 to 10 year period through the initial installation design.

d) To provide visual performance higher in quality than "excellent" off-the-air reception.

e) To provide through a conservatively rated system excellent physical plant reliability alleviating prolonged or consistent outages. A well performing system, using today's technology and allowing for growth, will make it easier for the consumer to accept a new public communications medium.

f) To establish cable standards and performance characteristics of the cable system so as to allow time for the standardization of a higher performance television set and to avoid any immediate modifications of current television sets.

g) To provide a redundant path for a minimal number of channels to ensure that public access emergency channels are available as well as to provide the alternate video channels when outages occur.

h) To provide for an eventual reallocation of channels that may provide entertainment in one grouping and ITV and other services in another grouping.

i) To provide through the initial system design the capability for extending the resolution characteristics of a total system including the performance of TV receivers and program origination studio equipment. The necessity for wider channel allocations and the provision of the proper guard bands may be required for these systems.

j) To require no additional penalties to be imposed on the subscriber in performance, TV set operation, maintenance and cost.

k) To eliminate the possibility of radiation in frequency bands set aside for other federal or municipal services.

l) To lessen total system costs per subscriber in the initial and expanded system.

m) To include in the system planning concepts that allow for the inclusion of subscriber multiple distribution systems, as the ability of a single cable to carry multiple channels grows.

n) To provide a system for two-way services that allows the addition of peripheral systems to be included as a minor percentage of total system cost.

3. Headend Signal Reception and Output

One of the basic functions of the headend is to obtain the signals from the various sources, internal and external, such as OTA transmission, local origination studio, educational stations, system controller, other headends and regional centers, and then output these on the local distribution system (multi cables, microwave, waveguide, etc.). Similarly, on two-way CATV systems it must receive the signals from the users, process these signals to the system controller, and provide the responses to the local distribution system (LDS).

Functional Objectives

a) Antenna systems of the height, gain and directivity necessary to obtain OTA signal with a high signal to voice ratio.

b) All incoming signals from OTA, local origination studio, microwave regional centers and satellites should be converted to a proper frequency for the LDS spectrum and multiplexed on to the LDS system with a minimum of noise and interference and at sufficient levels for best transmission. Maximum utilization should be made of the available LDS cable spectrum.

c) Two-way operation of the LDS should be accommodated and signals received from the LDS system processed and presented to their interface, e.g., system controlled, in the level and format required.

d) Digital transmission techniques should be used for data and control links. Digital TV transmission or reception should be used on long haul links to obtain maximum signal to noise ratios and reduced degradation of video.

e) Direct satellite interface through an associated ground station, receive only, should be provided where system size and economics allow.

f) Two-way satellite communication interface should be provided through a regional center interface.

g) The headend should contain all the facilities required for Pay TV operation in the system or the interconnection to such facilities if maintained separate from the headend..

h) A minimum of ten channels should be provided for ITV usage.

i) Bandwidth compression techniques should be utilized to obtain most efficient spectrum utilization.

4. Regional Center

The regional center provides the means to interconnect CATV headends on a regional basis. Further, it provides a central location for the installation of large system components and the intra region sharing of resources not economically within the means of individual CATV systems. The regional center also provides for the inter-regional connections and interconnection to a national center.

Functional Objectives

Through the development of regional centers interconnected to the local CATV systems, to other regional centers, and the national center, the regional center should provide:

a) The interconnection of large computers for interactive ITV delivery throughout the region.

b) A centralized program library for ITV programs and interactive CAI.

c) The sharing of resources to allow:

- --satellite ground station two-way interconnect to satellite communications systems;
- --large computer systems for interactive ITV such as TICCIT, and information storage and retrieval systems' data base;
- --studios for program generation and live programming.

d) Library of catalogued stored information available for access and automatic retrieval by authorized users.

e) Interconnection to CATV headends via cable, microwave, waveguide and optical means.

5. National Center

If a national center for ITV and educational programming is developed, a nationwide distribution system for the center's software can be most readily accomplished by a satellite link. This is not meant to preclude the use of non-electronic delivery means such as the U.S. Mail for certain items of distribution, including catalogs, brochures and direct mailings to schools, libraries and institutions. However, the satellite provides the means for economic delivery simultaneously to individual or many users over a widely dispersed national area, thus providing for the rapid and wide distribution of ITV programming from a centralized resource. The use of two-way satellite links allows the capability of satisfying material demand programming from the local CATV systems and their regional centers.

Functional Objectives

a) A satellite ground station interfaced to the National Center is to be provided which should supply video and frame storage type ITV channels for transmission to the systems for rebroadcast by regional and local CATV systems.

b) During low load periods it should provide ITV programming for automatic non-attended recording systems, either for individual users such as a school, or groups including schools, regional centers, CATV systems, data banks and computer memories.

c) Provide random access, narrowband channels via satellite for two-way communications of control information or data, requests, messages, TTY exchange, audio, computer to computer interchange, etc.

d) Utilize digital transmission and bandwidth compression techniques for maximum satellite transponder utilization.

e) Control of traffic for regional to regional interchanges via satellite can be provided by and from the National Center with a ground station serving as a routing center.

f) Reduce manpower for supervision and control.

g) Provide higher grade of service through demand assigned multiple access to ITV satellite channels. Include service options of television, teletype, facsimile, data and voice.

h) Accommodate hundreds of ITV stations in the Satellite Communication Network.

6. Information Storage & Retrieval

As the volume of data and data sources grows, the ability to store this data so that it will be easily accessible becomes more and more important. An ITV system should have the ability to obtain on demand specific programs, reference material or other information desired. Present methods of storage include libraries of books, films, tapes, computer memories and computer tapes. An overall ITV system should be capable of providing information in a variety of media forms because of the large scale investment already made by users, producers and system operators. The media are classified in two specific forms: local media and published media.

Local origin media are characterized by:

Simplicity of preparation
Limited quantity
Simplicity of organization
Limited duration of interest
Limited durability requirements.

Examples are:

Local TV programs
Advertising slides
Land Camera photos
16 and 8 mm movies
16 mm microfilm
Microfiche
4 x 6 opaque images
Magnetic or paper tape
Keyboard input

Published media are characterized by:

Elaborate preparation
Mass replication
Complex organization
Extended duration of interest
Substantial durability requirements

Examples are:

Network TV programs
Commercial movies
Professional commercials
Magazine and newspaper publishing
Programmed reference files
Study courses
Special purpose programs
Wire service data

Kodak and others such as 3 M and Bell and Howell have been working on and have brought to the market several automated systems for information storage and retrieval. These systems consist of microfilmed data that can be accessed by a terminal to obtain the specific frame to be viewed. An example of this is the 3M brand 400 and 500 series page search reader printers. These devices retrieve specific film images in seconds with digital keyboard input. They retrieve one specific image from a file of up to 10,000 images. Other systems allow the putting of computer tape data directly on microfilm and the direct generation of micro film or microfiche from the computer output. Large amounts of information are available in microfiche form, such as the NTIS and ERIC libraries. Thus microfiche is a ready source of information already stored in that form which can be utilized for automatic retrieval systems. Microfiche is usually in black and white.

The juke box is a system for automatic retrieval of audio records. The advent of the video disc allows a similar concept to be used for automatic selection of single video discs from a relatively large selection of discs. Each disc can contain up to an hour's program. Similarly, video tape cassettes can be placed in video carts such as the RCA TCR 100 or similar devices where one cassette out of a selection is chosen to be played. Recently a company came out with a video tape juke box concept and demonstrated a model to the broadcast industry. Further, the video tape or video disc can be indexed for single frame viewing so that single pages, photographs and slides can be viewed one at a time. The access time of the video disc is better than that of video tape, since the pickup unit can be moved radially across the disc as well as the track or groove moved under the pickup. With indexing and other control information, the disc can contain up to 90,000 single frames in color or black and white.

The capability exists now to couple the existing ISAR systems to CATV via the computer. This coupling is not without problems, one of which is the resolution of the conventional TV receiver. The resolution problem may be overcome by the viewing of a portion of the microfiche or slide and/or slowly scanning the frame. Higher resolution in the TV set is technically easily achievable but not without standard changes that would have repercussions throughout the TV industry, and consequently for this reason it will not be considered.

Another problem in the use of information storage and retrieval is the buffering requirement. There is a gross mismatch between the access time of an ISAR unit (1 to 20 seconds) and the time needed to transmit a frame (1/30 second). For thousands of users a buffering hierarchy is essential. Part of the buffering is the frame snatch capability of the user terminal. More buffering can be provided by video disc recorders and multiple ISAR units.

To date these information storage and retrieval systems have not had much use and impact on CATV systems, since these cable systems have been entertainment oriented. As CATV and Pay TV grow throughout the United States, the provision to the consumer of non-entertainment services and instructional TV will result in the coupling of automated information storage and retrieval systems to the interactive cable systems.

With the increasing use of broadband information systems there will be increasing markets for packaged image file data bases which can be accessed by hundreds or thousands of subscribers through a TV system. The growing pressure for larger data bases and faster methods of data retrieval requires the manufacturer, wishing to compete in this market of the 70's, to provide equipment with improved storage and retrieval technology. The projected technological advances to be discussed are in response to existing, and clearly defined, user needs. The cost/effectivenss of the image file system should be maximized to get the broadest market base. It is anticipated that a low cost static data image file (several hundreds of dollars in production quantities of a 1000) could be developed that would require replacement of data content several times a year. An extension of the basic system could be developed (at a higher price) with erasable features providing updated information as required (alterable read-only-memories ROM). The utilization of a unique data programming and replication method would insure large revenues in providing individually addressed frames and would also provide the basic foundation for a time-shared TV channel distribution system. The storage of large amounts of information that can be manipulated electronically was the basis of all modern data processing systems. This hierarchy of storage devices included punched cards, reels of magnetic tape, magnetic card memories, magnetic disc packs, drums, extended core, main core, film wire, and semiconductor memories. The state-of-the-art has many shortcomings for broadband information systems, including the requirement for distributing single video frames as well as digital data. Large individual frame storage capacity is presently obtained in devices with mechanical motion--making them slow, relatively expensive, bulky, and unreliable. The loss of time is particularly severe when randomly searching a large file.

Functional Objectives

The Broadband Information system requires the recognition of the potential sources for the national data bank, the recording media used, the equipment necessary to store and retrieve the data under user control, and the buffering of the data into the overall network.

a) The system should be modular to accommodate a variety of media and system sizes.

b) A wide variety of media are already available and standardization will be a long time in coming and may never be total. Until then the ISAR system must be able to accept these media and use them. Different media should be used for local origination of perhaps temporary interest, and for published data.

c) The system should accept the following types of media currently available:

--Network programs
--16 mm
--35 mm
--Electronic video recording film
--Video disc (Teldec)
--Video tape (transverse and helical scan)
--Computer tape
--Microfiche (24-150X)
--Microfilm

d) Users should have several modes of use of the system. Among the important parameters are the frequency of interrogation and the delay to the next frame. For a motion picture program, the user may make one interrogation (program request) and the frame delay is 1/60 second for the next hour. A person reading a "book" may request a new frame every 20 to 30 seconds. In searching a file, the user may request a new frame every five seconds to several minutes. In playing a game, or studying, the requests may be minutes apart. These several modes have a strong influence on the structure of the ISAR system and its buffering.

e) A new type of electronic random access memory combining holography, solid state sensors, optical technology, and simple mechanical devices, could possibly simplify the architecture and operation of broadband information processing systems. The essential initial characteristics of such a system should be:

--A static data bank containing single frame images
--Controlled random access by a computer/communications system
--The use of solid-state vidicon technology with integrated scanning circuits
--Rapid multiple access availability to time shared addressees
--A minimum of 10,000-100,000 single frame image capacity
--The high resolution video image should be capable of being received by user terminals having frame storage capability
--The image file should be capable of being prepared externally and should be up-dated by replacement
--Replication and production of the image file should require a low cost process
--Adequate effective speed to match the system controller (processor) of a future BIS system
--System eventually should have extensibility to provide erasable capability.

7. Local Distribution System (LDS)/Microwave Concept

Short-haul, FM microwave links for urban areas have been in various phases of development for some eight years. TV signals are beamed on a line-of-sight path to a receiving antenna, where they are then down-converted into normal, wired CATV distribution systems. The obvious advantages of microwave in rural areas are its utility in reaching areas considered prohibitively expensive for the installation of trunk cable. In urban areas, where it might be initially both expensive and difficult to dig up city streets to lay cable, microwave offers CATV system operators a very good potential return on investment in the initial hook-up phases. Cable operators can increase subscriber penetration with homes that would normally have been inaccessible by normal cable techniques or franchise arrangements. A microwave link can also reduce the need for multiple headends, and distribute signals to all parts of a cable system without the additional expense of running cable in areas where subscriber penetration is limited by geographical factors.

Microwave systems are also being used for two-way configurations similar to cable for accomplishing remote origination. Programs generated at a remote source are fed to CATV MATV headends via microwave loops, since the laying of cables would not be economically viable.

Functional Objectives

The Broadband Information System Development requires that future systems be compatible with microwave and wave-guide distribution media, and be able to accommodate hybrid distribution frequencies. This would permit optimum performance at minimum construction and operating costs in both high-density and low-density TV household areas.

a) To provide a system gain consistent with a ten mile radius path and 99.99% annual rainfall reliability as experienced in the Gulf area.

b) To provide for gross simplicity, requiring a minimum skill for additional channel implementation. As channels are added no down time or performance defects should occur.

c) A minimum equipment profile that would make sure the equipment was attractive as well as safe. Servicing technique should be via replacement type procedures using a modular concept for test and maintenance. Automatic test equipment for test, monitoring and fault analysis should be included.

d) To provide the technology that would slow down obsolescence through the maximum use of state-of-the-art components.

e) To provide high quality video and voice technical quality standards, up to an eventual goal of 24 channels per radiator, and a return channel capability for full two-way system operation.

f) To have available a low-cost repeater capability which would provide minimum contribution to noise and traffic performance in order to effectively penetrate both urban and suburban distribution markets.

g) To make maximum use of multiplexing of voice and video signals on a single RF carrier.

h) To operate under difficult environmental conditions without the need for forced air cooling.

i) To delete the maximum amount of antennas and terminal receivers which contribute significantly to system cost and to keep system fade margin to a minimum.

j) To provide a relay system, reducing the number of high power transmitter installations which are required to provide 100% coverage in shadow areas, as well as covering the possibility of new construction being placed in the radiated path. The flexibility to accommodate changing physical environments is, therefore, needed.

k) To provide for the interfaces needed for use with telephone, MATV and general purpose industrial systems.

l) To provide a high MTBF to guarantee a reliable system.

m) To remain within the FCC constraints for antenna size.

n) To provide systems for signal distribution as well as for use in program origination configurations.

8. System Controller

A wide range of services should be made feasible by combining cable television (CATV) with a time shared, interactive computer-controlled information retrieval and dispensing system. The convenience of having this information available on demand, and not scheduled, is important to the successful marketing of these new services. The system services to be supplied should be available to the home consumer, industrial consumer, schools and school systems, and commercial consumer. Four discrete video channels could be dedicated in each of these four categories of service. The initial services provided should include:

--Home Consumer Services

Restricted Programming - Pay TV
Interactive Programming
Security (Fire and Burglar Alarm)
Audience Reaction Polling
Performance Monitoring
Subscription Television
Utility Meter Reading
Interactive Education
Merchandising

--Schools and Institutional Services

Security (Fire and Burglar Alarm)
Video Surveillance
Videophone (Duplex)
Interactive Education
Restricted Programming
Interactive Programming
Performance Monitoring
Reaction Polling
CAI

--Industrial Consumer Services

Security (Fire and Burglar Alarm)
Video Surveillance
Videophone (Duplex)
Interactive Education

--Commercial Consumer Services

Videophone (Duplex)
Data Transmission
Point of Sale
Transactions

Functional Objectives

In the future operational system, the entire computer facility will probably consist of several specially selected low-cost (less than $40,000) high-speed minicomputers and their associated low cost peripherals. When fully developed the System Controller should provide the following functional objectives:

a) Low cost, programmable communications processor which controls the CATV data communications network and the traffic transmitted over it, as well as the multiplexed line concentration of signals from a large number of subscribers;

b) Required bit to character, character to message assembly, terminal control monitoring and message buffering needed for each of the identified services;

c) Modular communication peripheral interfaces and controls (tape, disc, typewriter, teletype) which will be compatible with the basic processor application used in a system;

d) Incremental growth capability of the processors and the compatible peripherals to handle large storage and processing problems inherent in more complex system operations;

e) Dynamic memory allocation of variable buffer lengths whose size is selected by the system requirements including the addressing methods needed to permit rapid access to entries in tables (tables contain status information for each of the communication lines and subscriber terminals);

f) Capability of interfacing with larger scale computer systems for off-line processing of data through the use of compatible software; (modular application software packages which will complement the system hardware and allow the user to specifically and economically fit the needs of his application);

g) Capability of read-in read-out of serial bit data through the communications message system of information, interface, and control data via one input-output queuing system;

h) Computer control console and monitor which contains the necessary switches and indicators required for the manual control of the processor. It will provide for the displaying of internal conditions in order to trouble-shoot the processor or to test a new program. In addition, it contains the communications data set controls, and specifically designed interface hardware for different growth applications. It includes recording equipment and displays for monitoring total system activity. The control console can display to the system operator on request the status of any given subscriber terminal as well as the operational status of any part of the entire system. Using the manual control console keyboard, the operator can access individual subscribers to the software providing the services. All of the subscriber input possibilities should be displayed on the console display. Examples of information available for display and/or recording include:

--System fault detection and location
--Subscriber address
--Frequency checks
--Program log
--Channels being selected
--Time on channel
--Alarm signal and location
--Utility meter usage
--Polling of consumer response.

i) The use of basic software package including a basic input-output executive control system plus specifically developed application programs. Initial application programs will be basic on-line polling programs designed for CATV operator usage. Software developed must be compatible with multi-manufacturer large scale processing systems. Data is recorded for on-line and off-line processing by the use of magnetic tapes and disc storage devices. Their control electronics should be included within the system. Console typewriters should also be available as information inputs to the system.

j) The processing of data off-line at a large scale processor, and the shift to total CATV system on-line processing with compatible growth software, by using the communications message system to switch and communicate the data to a large scale computing system. The communication path can evolve from the use of telephone transmission to wideband transmission via cable as it is installed. The queuing requirements of the processor (storage forms) will grow as the numbers of subscribers grow and the system needs to handle a larger quantity of on-line customers requesting "clean channel times" or dedicated video and digital channels. Polling complexity as a function of the programmed subscriber services will grow and must be related to applications software development.

k) The use of on-line types of software including:

--A standard on-line billing poll in which all subscribers are monitored.

--A subscription poll for those who have restricted access to special programs - for example, Pay ITV.

--A metering poll - monthly charges.

--An audience response poll to tally responses from audience initiated inputs.

--Security emergency sub-routines.

l) The use of off-line application programs including:

--Add and delete subscribers tables
--Billing functions:

- Security
- Meter
- Merchandising
- Education
- Health Services.

m) The computer/communications control of the simultaneously growing information storage and retrieval system should be handled through the system controller. The ISAR system growth should respond as the need for video information grows. Subscriber demand programming of video data will initially be handled by prerecorded video cassettes using video tape, disc, EVR, etc., and distributed via local origination studios. The equipment to be controlled at local origination studios will include studio and remote video cameras, film and slide equipment, video switches and video cassette systems.

n) Interactive communications through the use of a single dedicated channel to the system controller during the full time of inquiry; in this system each customer will be on-line to the system controller at all times. By on-line it is meant that the system can respond to a customer's signal within 20 seconds from the time the customer initiates the request. The system is meant to handle 10,000 to 100,000 customers.

o) To address advanced ISAR systems containing discrete image data stored in random accessed computer type equipment. The system controller will be required to select discrete and motion video, voice and digital data from storage mediums.

p) To receive data inputs from a low cost keyboard system providing encoded digital signals for requesting video data, Pay ITV, ASCII code transmission via the communications message system. Terminal devices will be incrementally expandable as system services develop.

9. Communications Message System

There is a need for a Communication Message System to operate in conjunction with a systems controller to provide the future system/service requirements for:

a) The Educational Consumer
b) The Industrial Consumer
c) The Commercial Consumer
d) The Home Consumer.

The basic communications message system (CMS) is a communications network overlay that provides for digital, voice, and video communications necessary for two-way performance and provides the essential monitoring, control, service and technical control functions.

The monitoring functions include: a) the monitoring of TV channels being viewed by subscribers, polling all sensors (burglar, fire, utility meters) and user selection status; b) the status of all system operational equipment and critical system performance characteristics (out of band noise, frequency, etc.) for FCC and maintenance purposes; and c) as the capability for polling program logging data available at the local origination studio. This is accomplished by having home terminals, CATV amplifiers, headend equipment, local origination studios and other system elements equipped witn responsively addressed digital systems to indicate status, location of malfunction, transmission failure and in general any on-line maintenance or system operational data desired to be polled by the communications processor.

The control functions are to control channels to subscribers (on, off, degrade, selective) to control remote origination signals entering the system, to provide the means for restoral (rechannelizing signal) where backup is available. Depending on the system, there will be networking (switching) as well to microwave interconnects and satellite earth stations.

Service requests are those functions initiated by the subscriber such as keyboard generated alpha-numerics, voice and video inputs, and digitally encoded selection signals.

Functional Objectives

a) The basic communication message system should provide for four types of message capabilities in its channel allocations, such as:

- --Channels for two-way digital data link
- --Channels for narrow band two-way voice capability
- --Channels for standard CATV video distribution
- --Channels for video service channels (still frame or motion video).

b) The spectrum as presently allocated on cable may be able to provide the possibility of 17 additional channels outside the currently used CATV band. These channels can be selected from the following frequency bands:

- --Mobile Communications Band - 30 MHz to 54 MHz
- --FM Broadcast Band -- 88 MHz to 108 MHz
- --Aeronautical & Mobile Band - 108 MHz to 174 MHz.

c) The individual subsystems which should be able to operate in conjunction (input-to-output from) with the communication message subsystem should be:

- --Image storage and retrieval
- --Digital to video conversion
- --Buffer stores
- --Varied transmission media
- --System controllers (minicomputers)
- --Modems
- --Home CATV receiver terminals
- --Video surveillance systems
- --Local distribution microwave
- --UHF/VHF over-the-air
- --Multi-Point Distribution system
- --Satellite
- --Long haul point-to-point systems
- --Digital video transmission systems
- --ITFS
- --Radio broadcasting system
- --Special transmission systems, CCTV, MATV, Pay-TV
- --Audio intercommunication systems
- --Building automation systems
- --Peripherals (tape, disc, teletypewriters)
- --Printers.

d) Maximum use should be made of currently available single and dual cable systems, standard UHF and VHF systems, and hybrid systems involving switching and multiplex. The systems should interconnect with the following building units:

--Schools
--Large scale apartment houses
--Industrial and office complexes
--Multiple dwelling units
--Hotels and motels
--Single dwelling units.

e) The system should provide the optimum cost per subscriber for the performance and installation required and should be implemented in accordance with timely consumer acceptance of new features such as

--soft-hard copy, continuous motion and single frame image distribution;

--complete two-way interactive network for industrial, commercial, and consumer users;

--capability for growth (one-way selective, two-way selective, interactive).

Digital transmission of video started in the 1960's as a means of communicating satellite information via television. The quality of the signal was unappealing to the commercial television market. In the early 1970's Comsat and companies such as RCA and G. E. began experimentation on systems to be used in broadcast and satellite systems in order to provide bandwidth conservation and better utilization of assigned spectrum. Currently available systems require large quantities of digital equipment to accomplish video-bandwidth compression. Future systems using new technology available in integrated circuit form will make this technique more cost effective. A large number of new services could be provided even with poorer quality reception if the perceptual capability of the viewer and his specific needs are properly evaluated. For example, X-rays to doctors for consultation via satellite or telephone connection. G. E. is planning to experiment with its SAMPLE DOT system in various cable communities. Comsat is actively promoting its DITEC system for satellite links, and microwave companies such as Laser Link Inc. are using digital modems to provide longer haul capability for their system.

Functional Objectives

a) To provide a system for economizing in bandwidth and cost, and to provide an interconnect system for use in Cable TV, Local Distribution Systems, Multi-Point Distribution Systems and satellite transmission.

b) To provide multiple channel capability at a variety of data speeds, capable of being displayed with sufficient quality for independent users.

c) The capability of coupling into standard cable TV systems, microwave systems from 2 to 12 GHz and through FM satellite systems. To be able to provide the video-base-bandwidth savings with only a very small loss in horizontal resolution.

d) To be capable in the long range of providing digital quality objectives close to that currently achieved by analog systems used in commercial broadcast services.

e) To be compatible and to incorporate communication systems which include time division, multiple-access techniques and other military and commercially available digital data transmission systems.

f) To reduce the disturbance problem that may exist between satellite and terrestrial systems, and have the ability to provide compatible conversions from a variety of digital communication languages so that any future service could also service the business, institutional, educational and defense users.

11. Satellite System

A satellite system distribution system should provide to ITV a wide capability in the simultaneous delivery of large amounts of programming nationwide at a low cost per channel-hour and in a timely manner. With two-way capability, demand programming, the capability of the user to request and get the program he wants should become available with the increased number of channels in a dedicated satellite system. One of the major contributions of a future satellite system will be the capability to utilize low cost mass produced ground stations.

Functional Objectives

a) Provide the needed nationwide coverage to allow for demand access to a significant percentage of Uplink Channels and to serve rural and isolated areas.

b) To have the capability of providing one-way reception of multiple ITV channels and the capability of selecting these channels by multiple users.

c) To be capable of providing two-way relay communications capability including voice, data and television.

d) To have an orbital life of greater than 10 years and to provide the required flux density to allow for the use of inexpensive modular ground terminal capable of being interfaced with local CATV systems.

e) To provide redundant transponders for failure recoveries in orbit, and to provide easily installed ground stations which have a high mean time between failures, and which allow for fast and easy maintenance.

f) To provide for a low cost per channel hour per user, especially for CATV systems, and to provide the incentive for national program distribution and resource cost sharing (Common Carriers - CATV Broadcast-Time Shared Networks, etc.).

g) To provide for interference-free reception especially from the local network systems.

h) To provide for the implementation of demand programming through a user priority system.

i) To provide for interfaces with the TICCIT, Plato type systems by allowing for the computer-to-computer transfer of video information.

12. Overall System

A conceptual schematic of the overall broadband information system is given in Figure 7-24.

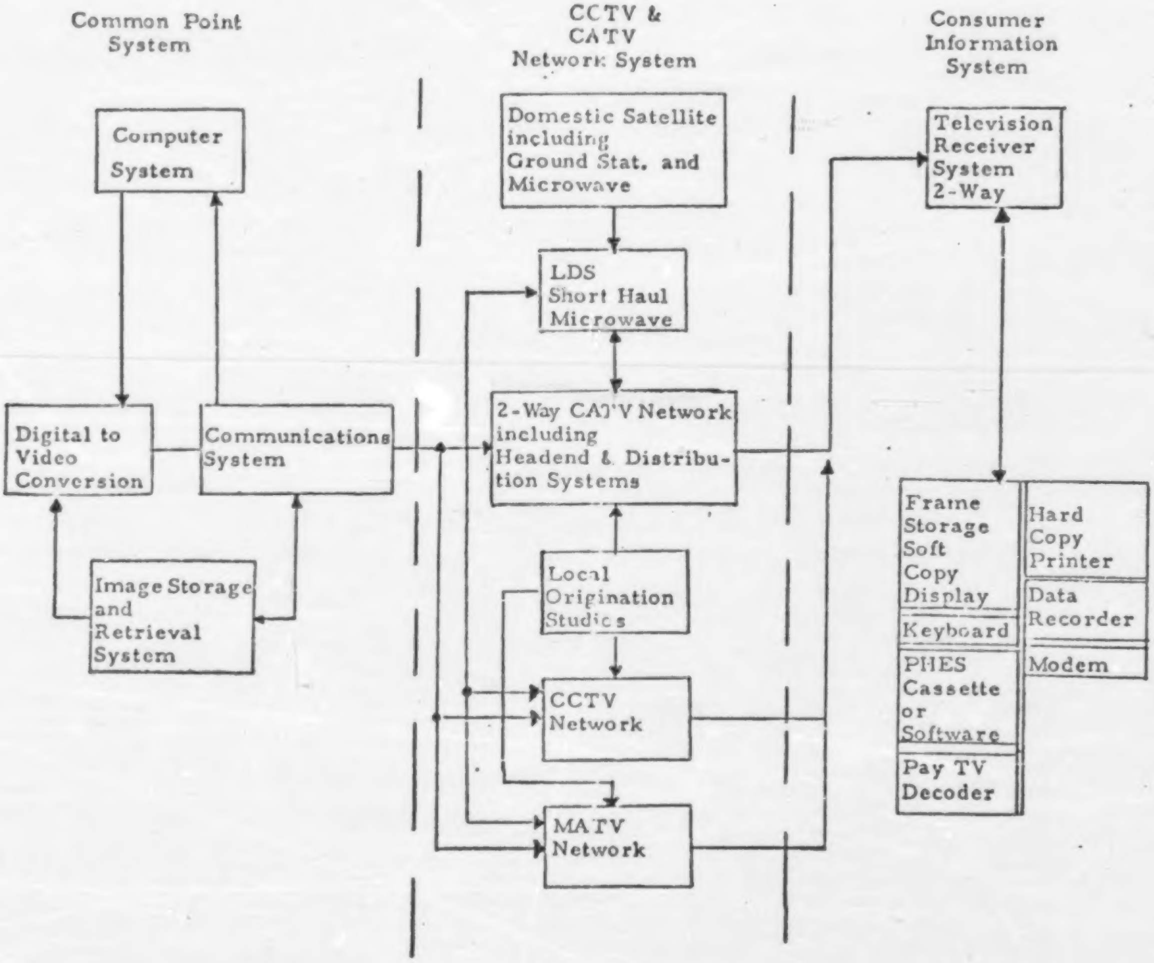

Common Point System
CCTV & CATV Network System
Consumer Information System
Computer System
Digital to Video Conversion
Communications System
Image Storage and Retrieval System
Domestic Satellite including Ground Stat. and Microwave
LDS Short Haul Microwave
2-Way CATV Network including Headend & Distribution Systems
Local Origination Studios
CCTV Network
MATV Network
Television Receiver System 2-Way
Frame Storage Soft Copy Display
Keyboard
PHES Cassette or Software
Pay TV Decoder
Hard Copy Printer
Data Recorder
Modem

Figure 7-24 Broadband Information System

7.4 Individual System Costs

A complete presentation of the cost of the individual distribution systems is necessary before they can be combined to form a variety of network configurations. The eleven major subsystems whose cost elements are presented in this report include:

1. CATV
2. Pay TV
3. CCTV
4. Video Disc
5. Video Tape
6. UHF Broadcast Station
7. ITFS
8. Microwave Systems
9. Satellite Systems
10. Computer Assisted Instructions (TICCIT and Plato Systems).

The above system costs are broken down into a set of cost elements, which are summaries of several cost classifications and represent an aggregation of identifiable equipments, services, or facilities. These costs will also be identified by those that are fixed costs and those that are variable costs. Since fixed and variable costs mean different things to different people we will define what we mean by fixed and variable costs.

Fixed Costs: Costs which are incurred regardless of the level of output or production. Such costs are either fixed because they are incurred before production can proceed and cannot be "retracted" (e.g., research and development) or are incurred because there exists a basic minimum production unit which must be established whether production is only one output unit or N units (where N is the maximum capacity output of that fixed production unit). Examples of the latter type of fixed cost would be payroll costs for a basic minimum personnel group, or basic physical plant or office. To define fixed costs by another rule, one might say that any cost which is not reduced as production is cut back is a fixed cost.

Variable Costs: Costs which vary directly with the level of production or output. In other words, costs which are reduced when the level of output is reduced are variable with the level of output (e.g., raw materials costs in manufacturing activities). Although variable costs by definition increase as production increases, they may not be directly proportional. Furthermore, variable cost increases may be discrete (in the algebraic sense) rather than continuous. That is to say, the increase in variable costs may come in jumps, with total variable cost being the same over some fixed range of output, and then jumping again as some known threshold in output is reached. The classification of specific items as fixed or variable cost components depends on the time horizon considered, and what elements of output are considered "variable" or flexible. In the long run, all costs are variable including the size of a physical plant or studio. In the short run, the size and therefore cost of a physical site may be fixed either because of leasing arrangments, costs of moving around to different sites, or where the ownership of a given building's space is not easily altered or available to be used for other purposes.

To use the individual system costs it is necessary to specify a system configuration of the size and capability required or desired and then assemble the individual cost elements together to reflect the entire system. One of the methods of gathering the elements together is to construct a simplified system block diagram identifying the system components. The computer cost model configured in this study then becomes a tool to exercise this system configuration to obtain cost estimating relationships, cash flow, capital required, etc. The Appendix provides several illustrative examples of the use of these models in providing operating cost evaluations. If the system to be used is an existing system, then we may be interested in the additional costs required to add a channel to that system to provide the additional service desired. Some systems are inherently single channel such as a UHF TV broadcast station. In this type of system if we have to add another channel we essentially have to add another complete broadcast station.

7.4.1 CATV

Basic CATV system element costs include the combined costs of the following elements:

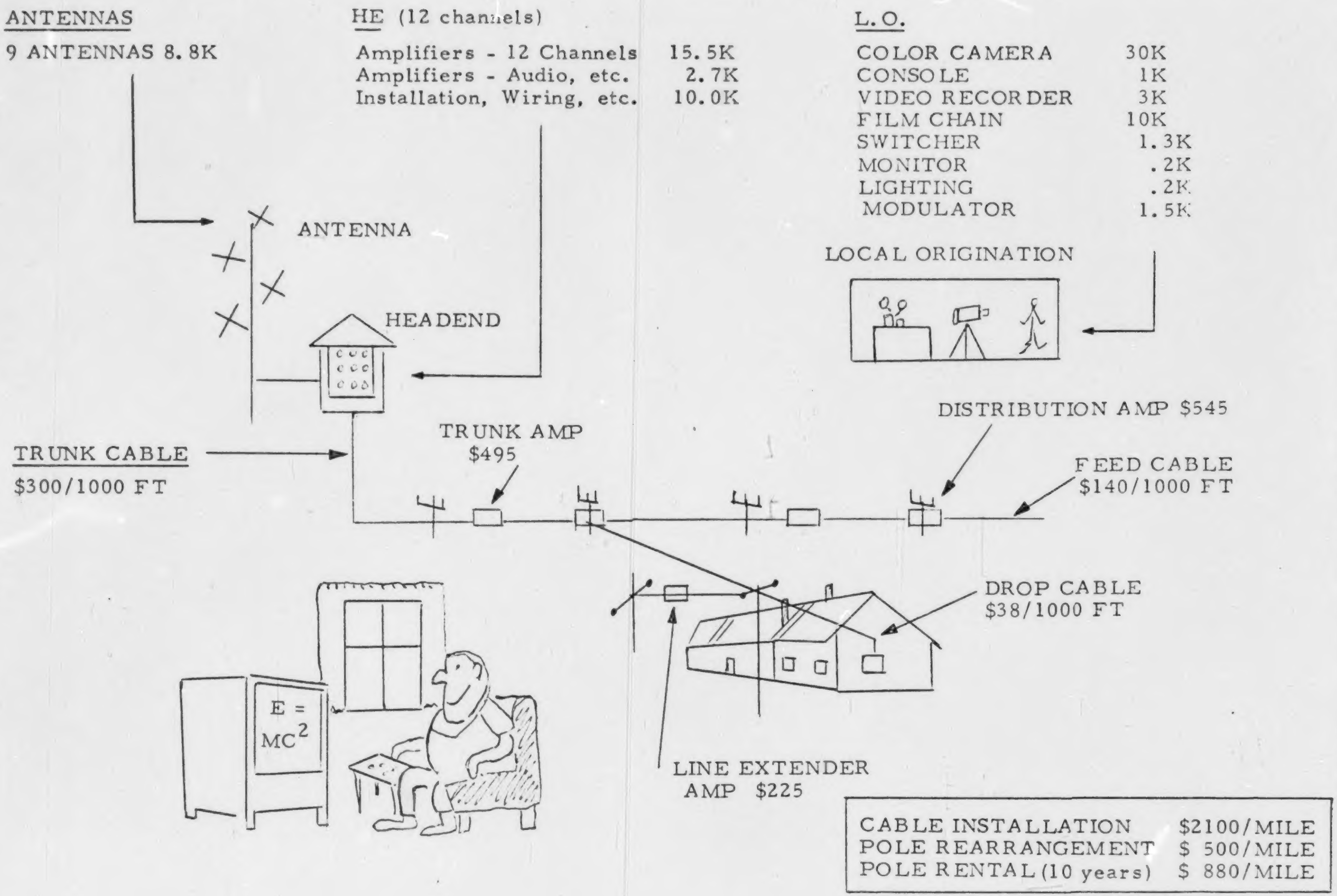
1. The Headend
2. The Local Origination (LO) Studios

3. Transmission Cable Systems
4. Units in the Home
5. The Various Interconnects Via Regional Centers and a National Center.

To operate a system in any area requires the payment of a franchise fee to the communities where the operation is desired. This fee is usually 5% of the total system revenue. The revenue generated by a CATV system accrues from the monthly charges made to the user for his connection to the system. This charge is usually about $6.00 per month. Additional revenues may be obtained from local businesses who have advertisements presented on the system. Generally this is a very minor source of revenue. Part of the pressure or desire to provide additional services to the consumer by the CATV system operator is the capability to provide increased revenue. Pay TV is one of the additional services that can be implemented for added revenue. Most added services require two way system capability.

Two things must be recognized in the use of cable TV systems: first, the time it will take before a majority of homes in the U.S. will be connected or passed by a cable; second, the additional time period required for the implementation of Pay TV and interactive TV systems on the cable. Projections for these systems in any cost model depend on the availability of capital to provide the implementation and to market the CATV service. Another factor in the switch to cable systems may be the demand for OTA spectrum for users other than TV, such as the land mobile service, who cannot satisfy their communications requirement except by OTA service and whose present spectrum allocations are saturated and jammed with users. The costs that follow are based on hardware available today, or manufacturer predictions of hardware costs. A simplified diagram to show a model definition of a CATV/Pay TV and its cost structure is shown in Figure 7-25.

The equipment required for the CATV headend consists of the antenna system, the amplifier system, including converters, preamp, equalizer and signal processor, in addition to other simplified equipment including combining networks, audio equipment, and directional couplers and splitters. Other costs include the mechanical


ANTENNAS
9 ANTENNAS 8.8K
HE (12 channels)
Amplifiers - 12 Channels 15.5K
Amplifiers - Audio, etc. 2.7K
Installation, Wiring, etc. 10.0K
L.O.
COLOR CAMERA 30K
CONSOLE 1K
VIDEO RECORDER 3K
FILM CHAIN 10K
SWITCHER 1.3K
MONITOR .2K
LIGHTING .2K
MODULATOR 1.5K
ANTENNA
HEADEND
LOCAL ORIGINATION
TRUNK CABLE
$300/1000 FT
TRUNK AMP
$495
DISTRIBUTION AMP $545
FEED CABLE
$140/1000 FT
DROP CABLE
$38/1000 FT
E = MC^2
LINE EXTENDER
AMP $225
CABLE INSTALLATION $2100/MILE
POLE REARRANGEMENT $ 500/MILE
POLE RENTAL (10 years) $ 880/MILE

CATV/Pay TV Cost Structure

Figure 7-25

hardware, and the installation charges. These represent the non-recurring costs. The recurring costs will include personnel to operate the headend and maintain the headend. A business office will also be required for billing, sales and administrative requirements. The cost breakdown is shown in Table 7-13. The cost for a local origination studio of moderate capability is shown in Table 7-14 and consists of the following studio equipment: camera, console, video recorder, film and slide chain, switches, monitor and lighting.

The facilities for ITV are already present in the many households that have cable television. The one way costs for the homes to receive CATV programs can be broken down as shown in Table 7-15. Costs predicted for two-way interactive elements such as a keyboard and video refresh memory are also shown.

A cable operator planning a new transmission system also incurs a tremendous initial expense in providing cabling, gaining overhead or underground access and installing amplifiers which must meet high performance standards. A transmission cable system cost includes all costs associated with the interconnection of the headend and subscribers. The cost elements for the transmission system are shown in Table 7-16.

7.4.2 Pay TV

As the name suggests, Pay TV systems are devised to allow billing a customer for program material he has selected and watched, unlike the monthly charge normally associated with CATV, which doesn't vary with the amount of time a set is used or the programs that are watched. There are many schemes for Pay TV that employ two-way operations: downstream for the TV and upstream for the billing information. Most schemes involve some sort of scrambling or signal processing that makes the signal viewable only by the authorized paying customer. The cost breakdown for a Pay TV system is shown in Table 7-17. The revenue generated by Pay TV is based on the programs. This charge can run from $2.50 or more for a film, based on comparable movie theater, box office prices. Sporting and

TABLE 7-13

HEADEND COSTS

QTY	Equipment/Service		Fixed Costs (in thousands of dollars)
1	12 Channel Amplifiers (see note 2)		15.5
-	Other Amplifiers consisting of:		2.7
	2/Combining Networks	$ 200	
	Audio Amplifiers	$2275	
	Directional Couplers & Splitters	$ 200	
-	Mechanical Hardware, Wiring, Handling		10.0
9	Antennas (12 Channels)		8.8
6	Technicians (9,000/yr)		54.0/year
6	Operators (7,000/yr)		42.0/year
2	Office Clerks (7,000/yr)		14.0/year
1	Administrator (12,000/yr)		12.0/year
1	Building Rental (2500 sq. ft. @ $6/sq. ft./yr)		15.0/year
1	Business Office Rental (625 sq. ft. @ $6/sq. ft./yr)		4.0/year

PLUS Headend Cost per Added Channel →

QTY	Equipment/Service	Variable Costs (in thousands of dollars)
1	Channel amplifier	1.290
-	Other amplifier	.225
-	Installation, mechanical hardware, wiring and handling	.828
1	Antenna and installation	1.250
-	Personnel added .2 man/yr.	1.800/year
	Cost per added OTA channel (see Note 7)	$5.393

NOTES:

1 These costs are based on a 12 channel CATV system.

2 These costs represent the conversion of OTA signals to the cable channel frequencies. Many systems now being installed have a signal processing group which consists of bringing the OTA signals to an intermediate frequency for signal cleanup prior to conversion to the cable channel. Cost for signal processing results in an approximate 100% increase in these costs.

3 Maintenance is performed by the technicians.

4 No programming is included in the above costs as it is derived from the OTA stations.

5 Sources of cost information:

Amplifiers, mechanical hardware and antennas - headend cost analysis from a CATV headend manufacturer.

Personnel cost - by interviewing operational managers.

Rental costs - by interviewing operational managers.

6 The costs above are considered fixed costs.

7 This cost is independent of number of subscribers per system.

8 Adding an OTA channel has no effect on transmission system and home costs.

9 Hours operation per day 16 hours.

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TABLE 7-14
LOCAL ORIGINATION STUDIO

BASIC CONFIGURATION (Notes 1, 2)

Equipment Cost	Fixed Costs
Cameras:	
• Black/white	$1,150
• Color	
1 tube camera	2,000 - 5,000
3 tube camera	30,000 - 50,000
Control Console	1,000
Video Recorders/Player	1,000 - 3,000
Film Chain	10,000
Film and Slide Chain (Broadcast Quality)	112,000
Modulator	1,500
Switcher	1,300
TV Monitor	200
Studio Lighting	200
Range of Facility Cost:	$47,500 - $175,000
Operations Cost	**Fixed Costs**
Programming (200 hrs @ 150/hr/film or tape)	$30,000
3 Operators @ $7,000/yr.	21,000
Studio Rental (1000 sq. ft. @ $20/sq. ft. /yr.)	20,000
	$80,000/yr.

PLUS:

Cost to Add One Channel for ITV Taped Program Material →

ADDED CHANNEL (Notes 3 - 7)

Qty.	Items	Variable Costs (thousands of dollars)
5	Video Tape Player (Sony VP 1200)	7.0
1	Modulator (EIE-CTM-2)	1.8
	Monitor (color)	.45
	Installation (Est.)	.5
.5	Personnel @ $9000/yr.	4.5/yr
	Programming @ $150/hour tape	156.0 first year 78.0 for succeeding years

Notes:

1. Operations costs are for a minimum configuration. Studio operation is 16 hours per day. The majority of the operation is a single panned camera presentation of time of day, weather prediction, plus some local information in single panel form. A very minimum amount of local programming, local talent and local events are provided.

2. These costs are independent of the number of subscribers per system.

3. Headend costs are not varied by this added channel. It is assumed that the amplifiers for this channel are available in the headend.

4. It is assumed that programming coursework is a one-way receive only type presentation. Programming costs are based on $150/hr. tape purchase price, 4 hours of programming 260 days/yr, plus an added 4 hour/day repeating of the first 4 hours. Weekend programming will be a repeat of the programming shown during the week. It is also assumed that 50% new programming will be shown each year.

5. For Pay TV it is assumed that no added costs are incurred for billing, that a Pay TV channel is available for use and no additional costs to the balance of the system result.

6. One video tape player is provided for standby, previewing, etc. The four other video players, VP-1200, have automatic rewind and start so that once loaded they will provide four hours of continuous programming without operator intervention. If only one video player were provided a cassette would have to be removed, a new cassette inserted each hour requiring more labor and an interruption to the programming. Two video players could be provided so that one could be reloaded while the other played. Use of a video cart such as RCS's TCR-100, which was designed only to handle 22 cartridges of two seconds to three minutes each, for automaticity is not applicable.

7. Sources of cost information are vendor catalogs and other reports and studies.

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TABLE 7-15

HOME COSTS (FIXED COST)

One-Way

	COST
Home Terminal Cost	$50
Installation Cost Per Home	$25
Maintenance Cost (Estimated)	$12/year
Home TV Sets (Color or B/W)	(already exists in home)

Two-Way Interactive

Home Terminal (Including keyboard and Video Refresh memory for single frame storage)	$150
Installation Cost Per Home (Includes 2-Way Tap and dual drop cable)	$45
Maintenance Cost (Estimated)	$14/year
Home TV Set (Color or B/W)	(already exists in home)

Notes:

1. The home terminal cost reflects the use of a set-top counter or A-B switch.
2. These also approximate the costs to add a subscriber to the existing cable plant, in which case they represent variable costs.
3. The installation cost assumes that this is an overhead installation (not buried). Labor rates in cities such as NYC and surrounding areas could increase the installation cost per home considerably.

TABLE 7-16

CABLE TRANSMISSION UNIT COSTS

ITEM	COST
Trunk amplifier *(required every 1500-2000' of trunk)	$470
Trunk amplifier (agc)*(n every 8th amp on trunk)	$560
Trunk/bridger *	$880
Trunk/bridger (agc)*	$970
Distribution amplifier *	$410
Cable installation* (overhead, not buried)	$2100/mi.
Coaxial switch	$3.50
Trunk cable	$300/1000 ft.
Feeder cable	$140/1000 ft.
Drop cable	$38/1000 ft.
Pole rearrangement	$500/mi.
Pole rental (10 year)	$880/mi.

* Dual Cable Application

Notes:

1. The above costs represent the unit costs to be used with a strand map in implementing the cable transmission system for a CATV system. Each system varies in layout and subsequently costs.

2. The above costs are for use in overhead (on poles, telephones or power) installations.

3. Vendor catalogs such as EIE or Jerrold Corporation and cable manufacturers provide the source of cost data.

TABLE 7-17
PAY TV COSTS

	ITEM	COST
1.	Facility Costs	
	Encoder	$155,000
	Computer	150,000
	Video Tape Players & Control	19,000
		$324,000
2.	Programming, 1500 hours annually (Fixed)	$101,000/year
	(Direct)	649,000/year
3.	Maintenance	$ 80,000/year
4.	Facility Rental (2500 sq. ft.)	$ 14,000/year
5.	Personnel Cost (Estimated minimum operational personnel)	
	3 Operators @ $7,000/year	$ 21,000
	1 Technician	9,000
	1 Office Clerk	7,000
		$ 37,000/year
6.	Marketing & Advertising	$396,000 (first year)
7.	Pay TV Home Costs	
	Home Terminal* (Including VRM & Installation)	$150/home
	Annual Maintenance/Home	$ 12/year (estimated)

---

1. The functions of the home terminal are to decode, convert, select and bill for the Pay TV viewing. The VRM (frame grabber) is a device which permits a video lock to enable the user to view a single frame presentation.

2. The source of this cost information is Ira Kamen, Questions and Answers about Pay TV, Howard Same & Co., Inc., 1973.

3. Costs assume that an existing cabling system, e.g., CATV or MATV, is used.

special events are also similarly priced. ITV programming would require a study to determine what price could be charged and the demand that would be generated for various ITV programming.

7.4.3 CCTV

Closed circuit television (CCTV) is a system of transmitting TV signals to receiving equipment directly linked to the originating equipment by coaxial cable, microwave relay, or telephone lines.

CCTV installations run the gamut from very simple ones consisting of no more than one camera with possibly a monitor to extremely complex, multilocational studio arrangements with switching capabilities permitting two-way audio and video communication.

The basic closed circuit television systems consist of three main pieces of equipment. These are the television camera, the video tape recorder, and the reproducing device.

The CCTV costs for a secondary school including a studio, the necessary internal cabling and leased telephone lines are indicated in Table 7-18.

7.4.4 Video Disc

The development of the video disc system now makes possible low-cost playback of color pictures, together with accompanying sound, on standard TV receivers. Even though the discs are generally recorded only on one side, their future projected cost - compared with competing tape systems - is attractive for the consumer market.

Essentially, the video disc is to picture-storage technology what the phonograph record was to audio recording. Like the phonograph record, the video disc provides a high-information density, low-cost recording medium, simple playback equipment, random access to any desired portion of a recording, and economical, high-speed low cost duplication.

TABLE 7-18

CCTV COSTS (SECONDARY SCHOOL)

	FIXED COSTS
STUDIO	
MONITOR, TV, 23 INCH	$ 450
CAMERA, B&W	1,150
DOLLY	70
TRIPOD	200
CAM HEAD	100
LIGHTING	200
CONTROL CONSOLE	250
SWITCHER	125
VTR, qty. 2	2,000
FILM & SLIDE CHAIN (OPTIONAL)	10,000
SCHOOL NETWORK	
CABLE NETWORK	$40/room
CABLE AMPLIFIERS	$300 each
TV SETS B&W	$250 each
LOCAL INTERCONNECTING CABLE	
ONE-CHANNEL	$750/mile/year
TWO-CHANNEL	$960/mile/year
FOUR CHANNEL	$1248/mile/year

Note :

The information was obtained from various vendor catalogues, and previously conducted ITV school system studies.

Production Costs Per Disc (100,000)

programming	$2-3
promotion	$2-4
disc material	3-5¢
recording (pressing)	1-2¢
	$4-7

Additional Disc Cost Data

cost of setting up new manufacturing facilities	$20-30 million
cost of modifying existing LP to disc manufacturing facilities	$2-3 million
cost of producing master disc	$1,000-12,000
pricing structure for video discs	$8-14
pricing structure for disc players	$140-300 (manual) $300-500 (automatic)

Table 7-19 provides an expanded estimate of disc costs for various quantities manufactured. It illustrates the way costs would vary for discs if the market expands, and includes estimates of associated general administrative and promotional expenses. Obviously, there is a large degree of uncertainty involved because the data comes from predictions.

7.4.5 Video Tape

Video tape will be used for the original recording of program material instead of film. It offers the cassette-type packaging that, in addition to providing handling convenience, will become more economical than the 35 mm and 16 mm films. At present, many electronic visual publishers/distributors are engaged in the creation, production, and distribution of video tapes, serving the different needs of viewers in entertainment, education, business, and the professions. For distributors one of the cheapest ways of converting to the video tape master from the movie film is to record the program on 2" quad tapes using the transverse or helical scan method. Then,

TABLE 7-19 VIDEO DISC COSTS

	COST PER DISC FOR QUANTITIES OF					
DESCRIPTION	100	1000	10,000	20,000	40,000	100,000
PROGRAMMING	200.00	20.00	2.00	1.00	.50	.20
DISC MASTER	40.00	4.00	.40	.20	.20	.20
DISC MATERIAL	.05	.05	.05	.05	.05	.05
PRESSING	.02	.02	.02	.02	.02	.02
PROMOTION & PKG.	100.00	20.00	4.00	2.50	2.00	1.00
OVERHEAD AND G&A - 25%	85.00	11.00	1.62	.94	.69	.37
TOTAL COST/DISC	425.07	55.07	8.09	3.71	3.46	1.84

Notes:

1. These figures are from rough cost estimates of projected costs and would vary from manufacturer to manufacturer and processes used.
2. Overhead and G&A is an estimate only.
3. Promotion costs are an estimate for illustrative purposes. ITV disc promotion might be considerably smaller. A marketing analysis would be required to determine best promotional methods needed for the subject and quantity manufactured
4. The programming costs used are $20,000.00 per half hour disc.
5. The disc master cost used is $4,000.00 each. Further, it is assumed that 20,000 copies can be produced from each master.

the 3/4" tape cassette units are duplicated from the master. These cassettes are distributed to the Pay TV and CATV operators.

Several Pay TV operators use Central Video Inc., which has a facility to copy master tape recordings and films and to replicate 3/4" Sony cassette video tapes for distribution.

The video tape system cost factors including programming costs and operator fees are identified in Table 7-20.

The home video tape-player system combines the conventional TV receivers with the distribution capacity made possible through video tapes. It consists of two simplified elements: (1) video tape-cassette and (2) the video tape player. A simple connection to almost any TV receiver completes the system. The home system cost factors are also shown in Table 7-20.

7.4.6 UHF Broadcast Station

The UHF broadcast system is another means of relaying the educational information to the users. This over-the-air broadcast service is available to the general TV viewing public.

The basic cost components are the capital and operating costs for (a) the broadcast station and (b) its studio. The individual cost elements include the transmitter and antenna cost which varies in the degree of coverage required for a city, a metropolitan area, or state and regional applications. More powerful 10kW transmitters would probably be used and joined in the state and region by some microwave interconnection network. Table 7-21 provides the costs for different configurations. Towers used to support the broadcast antennas have a cost which may be assumed to vary proportionally with height. The additional costs associated with implementing an additional single channel for a UHF broadcast station are shown in Tables 7-22 and 7-23. Typical studio equipment costs for a UHF broadcast station are presented in Table 7-25.

7.4.7 ITFS

Instructional television fixed service (ITFS) was established by the FCC in 1963, and was allocated TV channels in the 2500-2700 mHz range for use by schools and universities. Special receivers

TABLE 7-20
VIDEO TAPE SYSTEM COST

I	Live One Hour Program - programming and production	$10,000-$70,000
II	Copied Programs	
	Film Program Material (2 hr. color print)	$250 - $300
	Master Tape of Program (1 required)	
	Recording Cost	$750 - $1,000/hour
	Raw Stock	$200 - $250/hour

Replication from Master onto 3/4" Tapes -
One Hour Program:

Quantity	1 - 20	20-50	50-100	100-200	200 and up
Cost (ea.)	$50	$37.50	$30	$20	$15

Plus 3/4" tape cost (U-Matic) $25 each, 500 and up.

Film Distributor's Fee 35% to 50% of gross revenue from program viewer.

II	Home Costs (Note 2)	
	Video Tape Player - Sony U-Matic VP 1000	$900 - $1,050
	Video Cassettes - 15 minute to 1 hour program:	
	Purchase	$35 - $300
	Rental (2 weeks)	$3.50 - $30

Notes:

1. Sources of information were interviews with Pay TV producers, and cassette manufacturers' cost and data sheets.
2. Typical price range of programmed tapes offered by Sony.

TABLE 7-21

UHF STATION COSTS INCLUDING TRANSMITTER, TOWER AND ANTENNA

Probable Application	Power Avenue Station	Tower Height	Approx. Radius of Coverage	Cost Per Average Station
Local	2kW	300 ft.	20 mi.	$124,000
City	2kW	500 ft.	30 mi.	151,000
Metropolitan	10kW	800 ft.	40 mi.	280,000
Regional	9.2kW (avg.)	350 ft.	25 mi.	202,000

Notes:

1. The added height with the same transmitted power increases the radius of the coverage. Added power at the same antenna height increases the signal to noise ratio (reduced interference) at a fixed distance from the antenna. Signal coverage is primarily line of sight (neglecting terrain) from the transmitting antenna to the horizon.

2. Source of information for these costs is vendor catalogs and other reports and studies.

TABLE 7-22

OTHER UHF BROADCAST STATION COST (FIXED COSTS)
(Single Channel)

ITEM	COST
Control Console	$ 7,000
Input & Monitoring Equipment	$18,000
Test Equipment	$ 9,100
Spares	$ 8,000
Building & Land	$31,600
Installation	$30,000
	$103,700

Note:
Source of information for these costs is the Batelle report, November, 1972.

TABLE 7-23

UHF BROADCAST STATION ANNUAL OPERATIONAL COSTS (FIXED COSTS)
(Single Channel)

ITEM	COST
Engineer (5) 15,000/yr.	$75,000
Technician (5) 12,000/yr.	$60,000
Repair Parts	$10,000
Building Maintenance & Utilities	$ 1,800
Tower Maintenance & Utilities	$ 2,000
Insurance	$ 3,700
Total for One Broadcast Station	$152,500

Notes:
Sources of information for these costs are:

1. personnel cost - FCC report
2. other costs - Batelle report, November, 1972.

TABLE 7-24

UHF BROADCAST STUDIO COSTS

BEST COPY AVAILABLE

Studio Equipment Costs

Quantity	Item		Fixed Costs
6	Color cameras, broadcast quality		$480,000
	Video-Audio Switching Equipment		$150,000
2	2" Video Tape Recorders		$240,000
4	1" Helical scan video tape recorders		$ 40,000
1	Film/Slide Chain Equipment		$112,000
	2 film cameras 2 film projectors 1 slide projector Multiplexer Unit	Included	
	Audio Equipment		$100,000
	3 consoles monitors mike & speakers		
	Studio Lighting		$100,000
1	Remote Pickup Van		$350,000
	Includes 3 color cameras and a video tape recorder		
			$1,572,000

Operational Costs

Wages and Salary			Fixed Costs
2 Shifts			
	2 Directors	@ $12,000/yr.	$ 24,000
	6 Cameraman	@ $9,000/yr.	$ 54,000
	6 Engineers	@ $10,000/yr.	$ 60,000
	2 Light men	@ $9,000/yr.	$ 18,000
	2 Audio men	@ $9,000/yr.	$ 18,000
	2 Announcers	@ $10,000/yr.	$ 20,000
Office Staff			
	1 Administrator	@ $10,000/yr.	$ 10,000
	1 Clerk	@ $7,500/yr.	$ 7,500
	1 Accountant	@ $10,000/yr.	$ 10,000
		Total	$221,500

Programming		Variable Costs
	Films and Tape Cost	$174,000
	Artists (talent cost)	$ 9,000
	Royalties and License Fees	$ 57,800
		$240,800

Notes:

1. Source of information - vendor catalogs, station manager interview, and 1972 FCC Annual Report.
2. This studio is shared by 4 UHF stations.

are required for reception of the ITFS signal. The home TV receiver can't receive it directly. CATV operators may use special antennas and receivers to pick up special programs televised by the local ITFS station and transmit the programs over the cable system to the home. The capital and operating costs for an ITFS broadcast station and a receiver station are given in Table 7-25. Channel capacity is limited by FCC rules to 4 channels maximum. Financial support to ITFS stations are provided by individual schools, the school districts, universities and the federal government.

7.4.8 Microwave Short Haul Systems

Cost information is presented for the AirLink Systems which permit the transmission of multiple TV channels (or other information channels requiring broad bandwidth) on a single microwave carrier. This new dimension in microwave communications results in the ability to send much more information at a much lower cost than other systems. Two features of this system are extremely significant. One is the exclusive capability of the Airlink System to utilize the composite CATV signal anywhere along the route of the coaxial cable. The other is the exclusive relay or repeater feature for the local distribution of CATV signals. The Laser Link Airlink System can be used for extension of suburban and rural CATV headends to new pockets of population.

Laser Link's Airlink System consists of microwave equipment which includes specialized transmitters, specialized receivers, specialized relay equipment and conventional microwave antennas. For single "hop" multibeam transmission the QLL-12T (transmitter) and QLL-12R (receiver) are capable of transmission and reception of 9 to 18 TV channels simultaneously within the 12.7 to 12.95 GHz Community Antenna Relay Service (CARS) band. For additional hops, to extend the range of local distribution of CATV signals, the QLL-12TA repeater-amplifier may be used. For long-haul multiple hop, the QLL-5T and OLL-5R repeaters are available for transmission of 5 TV channels simultaneously. The equipment costs for the Airlink system are shown in Table 7-26.

TABLE 7-25

ITFS COSTS

ITFS Transmitter Station	Fixed Costs Single Channel	Fixed Costs Four Channels
10 watt transmitter	$12,000	$48,000
200' tower	$20,000	$20,000
Antenna	$ 3,500	$ 3,500
Waveguides	$ 1,500	$ 1,500
Test Equipment	$ 6,000	$ 6,000
Installation	$ 3,000	$ 5,000
Operator	$ 9,000/yr.	$ 9,000/yr.
Maintenance parts & insurance	$ 2,800	$ 5,000
Building and Land	$20,000	$24,000
ITFS Annual Operational Costs		
Engineers	$10,000	$20,000
Technicians	$ 8,000	$16,000
Power, tubes & repair parts	$10,000	$40,000
Building maintenance & utilities	$ 1,800	$ 4,000
Tower maintenance & utilities	$ 2,000	$ 2,000
Insurance	$ 3,700	$11,000
ITFS Receivers (Schools, CATV operators)		
4-channel down converter with antennas and tower	$ 1,500	

Note:

Signal distribution after reception at a school is by cable to rooms and areas where used. The distribution costs are approximately the same as CCTV cabling costs per room. A standard TV receiver can be used for viewing.

TABLE 7-26

LASER LINK MICROWAVE EQUIPMENT COST

Transmitters:	Fixed Costs
18-Channel Transmitter Model QLL-18T	$75,000
12-Channel Transmitter Model QLL-12T	50,000
FM Option	
12-Channel Repeater Model QIL-12TA	15,000
5-Channel Transmitter Model QLL-5T	25,000
5-Channel Repeater Model QLL-5TA	12,500
Custom Engineered Multicoupler	1,850
Receivers:	
12-Channel Receiver Model LL-12R	5,000
18-Channel Receiver Model LL-18R	6,000
Option 1R-TDA Preamplifier	1,500
Antennas: (See note 3)	
4 Foot diameter Parabolic Antenna (short path)	480
6 Foot diameter Parabolic Antenna	720
10 Foot diameter Parabolic Antenna	1,200
12 Foot diameter Parabolic Antenna (long path)	1,500
Towers and Facilities (See note 1 and 2)	
Repeater tower $138 per lineal foot (site can be top of building or other existing structure)	10,000
Repeater installation (estimated)	800
Land	1,000
Operational Costs (annual - See note 5) (per hop)	
Technician	125
Power	120
Parts	70

Notes:

1. Headend at either end of link already has an antenna tower which will be shared by the microwave system's antenna.
2. Physical space and facilities will be provided at each end of link by headend without increase to existing building.
3. As the path length from the transmitter location to the receiver location or repeater increases, increasing sizes of antennas are required to maintain adequate signal to noise ratios. Antenna diameter is selected as a result of a path loss analysis.
4. Vendor catalogs are the data source.
5. Operational costs are estimates.

7.4.9 Satellite System

There are two basic approaches to satellite links and costs. The first is to use the costs quoted by the proposers to the FCC for domestic communication satellites. The second approach is to use a new satellite resulting from the ATS-F experiments. In the domestic satellite proposals Fairchild has quoted prices of from $234,000 to about $360,000 per year per TV channel, and the rest of the applicants have proposed prices from $75,000 to $125,000. Hughes and GTE proposed CATV satellite services where the estimated cost to the cable operator would be $.25 to $2.00 a month per subscriber depending on the amount of programming. The ground station costs for building your own ground station is approximately $100,000 to $250,000 and would have a thirty foot diameter antenna. None of the choices above really provide a low cost source of a TV channel to the CATV operator.

The ATS-F experiment with HEW and CPB will involve a synchronous satellite accessed through a 500 megahertz bandwidth uplink in the six gigahertz band. The ATS-F will transmit down a number of frequencies, some of which are in the 2500 megahertz band, and its antenna beams will illuminate the Rocky Mountain region and/or Alaska, depending on the uses and conduct of the experiment. NASA conducted a cost-size tradeoff study with ATS-F for ground station sizing summarized in Figure 7-26. Plotted as a solid line is the function of gain-to-noise (G/T) ratio of the receiver as a function of antenna size. Plotted in the same figure with a dashed line is the cost of the ground station (for a moderate quantity) for the two dB G/T noise ratio of the receiver and antenna. An optimum cost configuration occurs at about an antenna size of three meters and a resultant ground station cost of less than $250 for quantities of a thousand. In making the comparisons, preliminary cost estimates of costs were obtained from major manufacturers of equipment, e.g., General Electric and Hoffmann Electronics. These indicated that the ground station could be emplaced for $500. Therefore a satellite that can provide the flux density of the ATS-F will allow the use of ground stations for $500, thus opening up

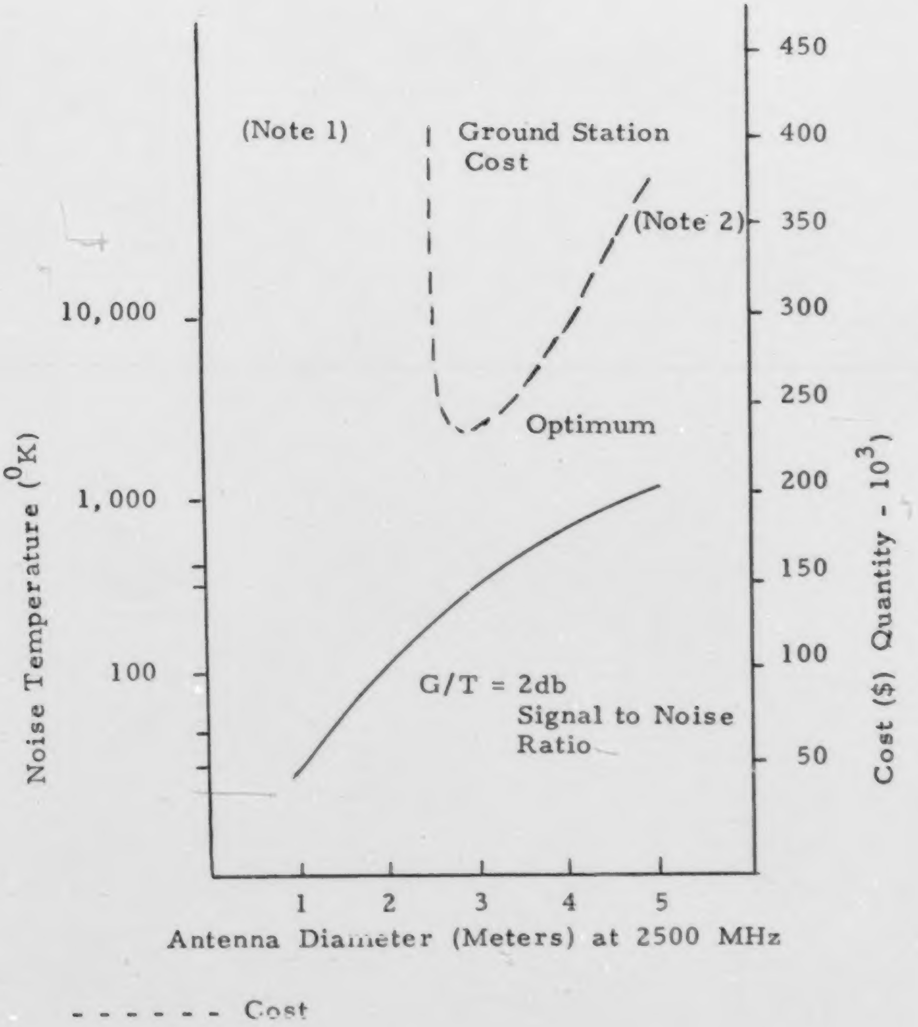

Figure 7-26 Ground Station Costs and System Noise Temperature

Note 1. Most expensive high quality reception and transmission system.

Note 2. Most expensive and complicated antenna required - least complicated receive/transmit system.

direct reception by CATV headends, schools, etc. The availability of such a satellite appears to be more than three to five years off.

7.4.10 TICCIT

The TICCIT is designed to interact with more than 100 students in school(s) at any one time. The system retrieves, on a time shared basis, various instructional data and provides an audio/visual presentation for the student at his color TV set. The student responds to the system by typing on a keyboard which provides another computer-generated audio/visual presentation. The TICCIT costs can be divided into three parts: Hardware costs (Fixed); Courseware costs (Variable) and Operational costs (Fixed). These costs are shown in Table 7-27.

7.4.11 PLATO

PLATO IV is not really an ITV system. It doesn't use the home TV receiver or TV display but a specially designed Plasma display estimated at $5,000 each. The high price of the student display console almost completely rules this system out for use in the home. The computer itself, for this system, is about $5 million. The system with four central processors (CDC 6400) can serve as many as 4000 terminal interconnections to the computer. Table 7-28 sets forth the projected operational costs for the PLATO IV system. The hourly costs are based on the assumption of full utilization of the system, with 4000 student terminals in less than 100 percent. This assumption is offset, however, by the fact that the hourly costs are based on an 8-hour day. The costs can obviously be lowered only by using the system for educational testing a larger part of the day (PLATO IV is currently in use for education at least 60 hours per week) or by using the student stations and the large, general purpose computer for other computational or research applications during the remaining hours. Thus, the educational use of the large computer could help pay for some of the other computational needs, and vice versa.

The greatest variance in the estimates of operational expenses lies in the projected cost of the PLATO IV student station

TABLE 7-27

TICCIT COSTS

Hardware

QTY	Equipment	Fixed Costs
1	Main Processor	26,000
1	Terminal Processor	21,000
1	Card Reader	4,000
1	Line Printer	11,000
1	Magnetic Tape Unit	9,000
2	Moving Head Disc Control	17,000
3	Moving Head Disc Drives	36,000
2	Fixed Head Disc Control	7,000
1	Fixed Head Disc Drives	5,000
1	CRT Terminal	3,000
1	Computer-to-Computer Link	3,000
1	Character Generator	7,000
1	Vector Generator	11,000
1	Keyboard Interface	5,000
20	Audio Response Units	60,000
1	Audio Response Control & Switching	10,000
128	TV Sets (Color)	38,400
128	Keyboards	19,200
128	Luminance	76,800
128	Chroma Refresh Units	11,000
128	Signal Processing Amplifiers	32,000
20	Video Tape Players	16,000
1	Refresh Control Electronics	10,000
	TV Modifications	25,600
	Total	$464,000

Courseware (variable cost)

4 Courses Remedial Mathematics Remedial English Freshman Mathematics Freshman English (50 to 60 hour terminal time required for each course)	1.5 million dollars
$375,000 per 50 hour course	

Operational Costs (fixed cost)

TICCIT Computer Room	
Programmer	12,000/year
Computer Operator	10,000/year
Audio/Visual Operator	10,000/year
Administrator	14,000/year
Spare parts & Test Equipment	20,000 (non recurring)
Maintenance - field Engineer and Spare parts replenishment	20,000/year

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Notes:

1. System may be interfaced to a two way cable system.
2. System integration and installation costs not included in the above table.

TABLE 7-28

OPERATIONAL COST OF THE PLATO IV SYSTEM

PLATO Subsystem	Annual Cost	Annual Cost per Student Station	Cost/ Student Contact Hour
Central Computer Facility	$900,000	$220	11¢
Software	$100,000	$ 25	1¢
Student Console		$360 to $1 000	18¢ to 50¢
Central Management Service	$240,000	$ 60	3¢
Communications Channels (Leased Cables, Telephone, Etc.)		$18 - $50	1¢ to 3¢

Assumptions:

1. 4096 student stations in operation
2. 8 hr. per day utilization of each terminal
3. Annual use per student 2000 hours
4. 8.2 million student-contract hours
5. Rental or amortization over 5 year period

(console). This uncertainty is due to the development status of the plasma display panel and the random-access image selector. Preparation of lesson material for PLATO IV would be only a few cents per student contact hour if as many as ten systems were installed in various parts of the country. The costs for installation of the computer (including the systems software) and management of the computer center would total approximately $1.2 million per year, or about 15 cents per student contact hour.

7.5 Cost Relationship Models

MATHEMATICA has developed, specifically for this program, a cost relationship model for a generalized CATV and Pay TV system. The flow charts of the model, an example analysis, and data outputs are included in the appendix. It is especially designed to evaluate the net cash flow and the present values of various systems, both in terms of technical configuration (i.e., the cost model) and financial operation (i.e., the revenue model). The concepts employed in the computer-based cash flow analysis are the standard ones used in the field of engineering economics. Other cost estimating relationships are easily added to the model for the specific outputs desired.

On the financial and marketing level, the ultimate viability of ITV rests upon market acceptance of the instructional services, delivered at costs that justify system implementation. The question of market success will ultimately be settled through the actual offering and marketing of home services. With this in mind, considerable effort should be provided in devising future system configurations that weigh and select factors consistent with the commitment of investment required.

ITV economic and financial studies involve a thorough consideration of cost/service/system combinations in conjunction with trade-off studies, and require major computational efforts. Although some computer programs that deal with cable television's economic viability are available, none were found capable of dealing with a hierarchy of service levels and alternate system strategies, including interactive computer-based services. To a great extent the implementation of ITV will be as a piggyback to the system developed for entertainment TV. Thus, an important class of cost model evaluation is one that would analyze proposed ITV services in terms of delta costs involved in the implementation of ITV.

We believe that for the home market ITV can be implemented through Pay TV/CATV systems, and therefore we have concentrated on developing this type of model. The origin of CATV has been its operation as a community antenna system for carriage of distant TV signals. If Pay TV/CATV is to serve as the transmission medium for ITV and other interactive services, then it must be evaluated within the economic and financial context of the existing cable television industry, the services it currently provides, and its prospects for the future. These prospects are necessarily limited by the expansion rate of the Pay TV/CATV market. An important aspect of Pay TV in delivery of ITV programming is the capability of billing the user for his ITV programming, thereby providing a source of revenue to support ITV. The planning model we describe in the appendix is general in nature and can be altered to arrive at delta costs. If we want CATV with the Pay TV capability excluded we simply enter zeros into the model for these elements. If we only want to look at the Pay TV costs and revenues we simply enter zeros or nothing in the other element. If we want cost per subscriber or revenue per subscriber, this would be added to the model, with two cards being inserted in the card deck and the output printed as desired. Any element of the model can be varied to determine its impact on the output relationships desired. Capability can be added, deleted, modified or changed by arrangement of the elements in the system configurations and their variation in the model. Elements can be modified by inflation factors, projection of cost trends such as the declining costs of minicomputers, or other predicted effects.

The major purpose of the cost relationship model analysis is to determine:

1. Total System Costs
2. Total Revenue

3. Net Cash Flow
4. Discounted Cash Flow
5. Present Values
6. Rate of Return on Investment

Moreover, the model can directly answer the question: What rates of return can be achieved if system costs, market penetration, and user charges are given? Also to be considered are how the revenues derived from the Pay TV system can be divided. A common split of revenues is shown below:

40%-50% to Distributor of Program Material
30%-40% to Pay TV Operator
10%-20% to CATV Operator.

Other cost relationship factors that can be easily derived from the model but not included in the example analyses are:

1. Net Cash Flow - a CATV Operator
2. Net Cash Flow - Pay TV Operator
3. Revenue - Program Distributor
4. CATV Cost/Viewer
5. Pay TV Cost/Viewer
6. Delta ITV Cost
   a) Programming
   b) Marketing
   c) Advertisement
   d) Equipment.

7.6 Decision Analysis Tools

The material contained in this report can be used to make policy and budget decisions on the HEW role in delivering ITV services by various distribution systems, with emphasis on delivery to the home. In this section we provide a methodological procedure for performing a comparative analysis. We have previously provided the description of various delivery and distribution systems and also the cost elements of these distribution systems. The computer cost models shown in the appendix demonstrate a method of configuring costs for different distribution systems. One of the most troubling assignments in this study was the development of a technique for comparing systems that would provide a pragmatic decision tool. We think the various systems can be compared by using cost components which are related to viewer-program-hours. This approach is based on the premise that HEW typically wishes to make this quantity as large as possible subject to its budget constraints. Generally speaking, the cost per channel-hour or program-hour per viewer depends on the specific configuration, program, and on the size of the audience. The following formula is useful in recognizing the interaction of the relevant aspects:

Number of viewer-program-hours = potential audience
x fraction of viewing time
x length of programs
x number of programs viewed.

The potential audience is the number of people who can be reached by a transmission. The fraction of viewing is the actual audience obtained with a particular program. The length of program is a measure of the average hours per program and the number of programs viewed is the average number seen by the viewing audience related to the specific program. Viewer-program-hours can be maximized only by balancing the investments made in each of the several components.

HEW investments or subsidies can be provided in the development of communication systems, in the operation of such systems, or in the development of programs. The system characteristics influence both the potential audience and the fraction which will view a presentation.

The program characteristics will influence the fraction of viewing time, the length of the programs, and the number of programs viewed. It is convenient to divide an analysis into the following three areas:

1. Communications system investment
2. Communications system operation
3. Program development.

This section of the study concentrates on points one and two.

In conducting a comparative analysis of systems for a specific policy or budget decision, the same series of steps are generally involved. These general steps are as follows:

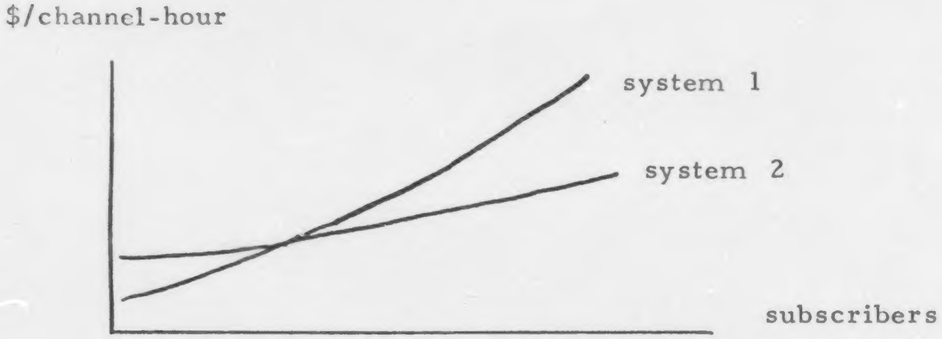
1. Configure alternative models
2 Determine cost per channel-hour and/or cost per channel-hour-subscriber as a function of the number of subscribers
3. Determine the fraction of network represented by the configuration
4. Scale the cost by this fraction
5. Determine the relative advantages of the alternative systems for the numbers of subscribers expected
6. Considering the alternative benefits, select one or more alternatives to obtain a balance in investment operations and programs

Alternative communication systems models are created by a communication system engineer or designer. The earlier sections of this report have described the principal components to be used. The cost per channel-hour or cost per channel-hour per subscriber is obtained from the tables and charts in this report.

Whenever the investment under consideration provides only part of the channels necessary to deliver a program to a viewer, it is necessary to determine the relative contribution of this part of the system. Thus, for example, if one is considering an investment in an microwave system, it must be recognized that while one or more channels may be provided, they reach only part of the way from the origination of the program material to the viewer.

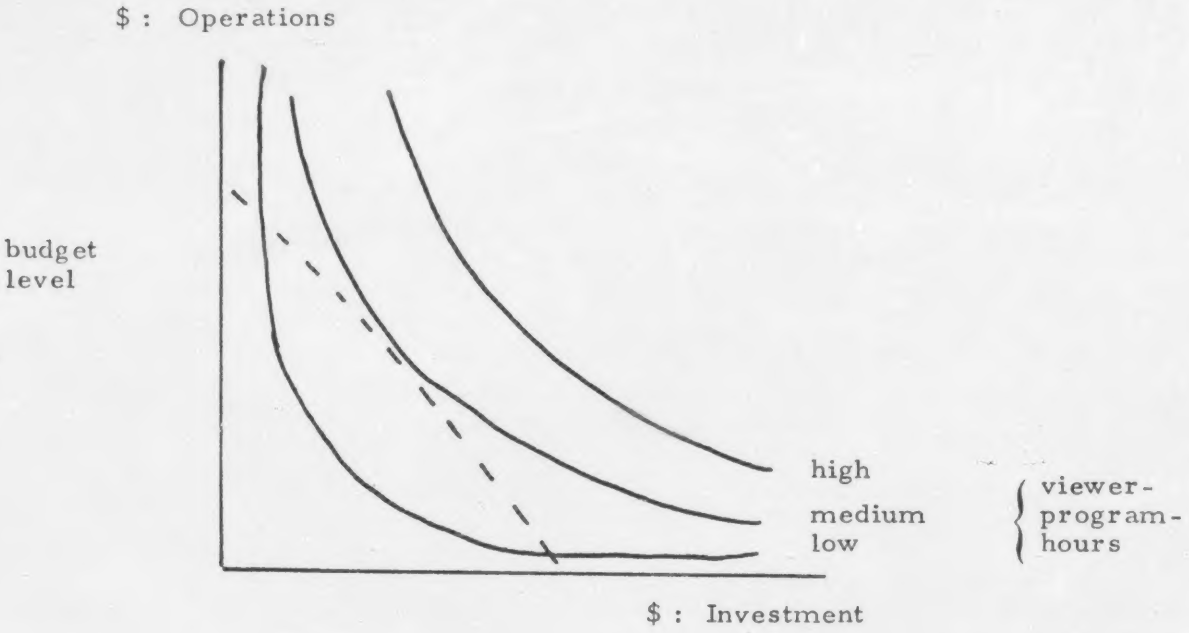
Items 3 and 4 on the list above provide for scaling the costs up to reflect the amount of the total system contributed by the particular alternative under consideration.

After the costs have been calculated and scaled, it is convenient to represent them in a chart such as that shown below:



Such a chart provides a method to determine, based on the number of subscribers, an optimal configuration from among a number of alternatives. Item 6 above recognizes that beyond costs, benefits are often different with different systems. Thus, after the cost comparison is made, it is appropriate to compare the relative benefits to determine the most preferred systems. In some cases a large number of alternatives may be under consideration which are not directly competitive. In this case it is appropriate to attempt to obtain a balance among the various categories. As an example, it would be inappropriate to spend all of the available budget on a satellite system if no programs were developed or no local distribution system were available.

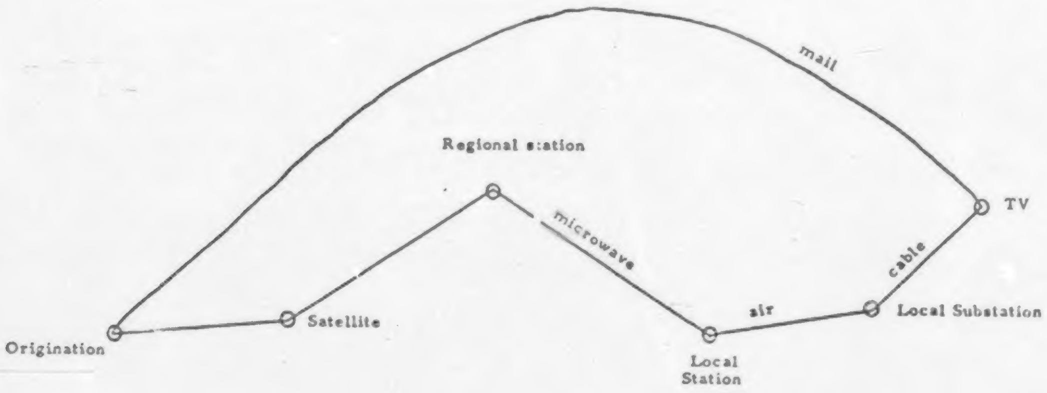
To illustrate more exactly what we mean, consider the following chart which shows the trade-offs between system investment and operation.



The solid lines show various possible levels of viewer-program-hours. Higher amounts spent either for investment or operations will increase this quantity. The dashed line shows one possible budget level.

Along a dashed line the total of the amount spent for investments and operations is constant. One seeks a point along a budget line such that the viewer-program-hours is largest. Thus, for the budget amount shown, the optimal level (the highest viewer-program-hours that can be obtained) is that shown as medium. This is the point at which the contour is tangent to the budget line. From this point of tangency the optimal amount to be spent on operations and the optimal amount to be spent on investment are read from the corresponding axes. Generally, it is not possible to obtain the viewer-program-hours contours explicitly. However, even in a qualitative manner this is the type of analysis which must be performed to determine the balanced or optimal utilization of HEW resources.

In describing the contribution of an investment in a communications system to the total delivery or distribution system we have noted that a particular communication model under consideration may not provide the complete system needed. In order to reach the local viewer a series of steps such as those shown in the following diagram may be required.


mail
Regional station
microwave
TV
cable
air
Origination
Satellite
Local Station
Local Substation

This distribution system can be characterized as being comprised of a number of nodes and a number of arcs. The nodes include, for example:

- ground stations
- satellites
- microwave stations
- broadcast stations
- TV receivers

Arcs in this network consist of:

- cables
- bandwidths
- non-electronic means such as mail.

To provide for delivery of a program it is necessary, of course, to have a complete set of links between the origination and the television reception. The purpose of the steps 3 and 4 discussed above is to make sure that the contribution of any arc or node to the delivery program material is properly rated by its contribution to a total system.

As described above, the HEW decision-makers need to be able to determine the system costs and the system benefits of alternative configurations. To provide for the convenient qualitative assessment of benefits a systems description effectiveness matrix has been prepared. This matrix is shown in Table 7-29. Each type of communication system is identified in this matrix, as are the many characteristics of each, so that the decision-maker will be able easily to determine the benefits associated with each.

The assessment of costs is performed by collecting the cost data associated with the components of a configuration model. This corresponds to steps 1 and 2 in the general analysis procedure. The result is one or more curves relating subscribers to cost per channel-hour or cost per channel-hour per subscriber. In the following section we present an example of an analysis such as might be performed for HEW in the future in support of its policy decisions.

TABLE 7-29

ITV SYSTEM EVALUATION CRITERIA MATRIX

	CRITERIA	OTA UHF TV	OTA UHF PAY TV	CATV ONE WAY	CATV TWO WAY	PAY TV (CABLE)
PEOPLE	Number of people served	ETV potential viewers include 85% of present TV homes (present signal coverage).	Very small. Few stations implemented for this capability.	10% of TV homes 1975 43% of TV homes 1980	All CATV systems eventually 2 way. No. of people now served by two way CATV small. Experimental systems in operation.	25% of homes on CATV systems.
	Characteristics of community	All areas served within reach of signal. Stations generally in or near population centers.	Experiments in chosen areas.	Poor OTA TV reception: urban, suburban and rural.	Poor OTA reception. Systems of over 2500 subscribers will use first.	Have installed CATV systems. More than 2500 subscribers/sys.
	User characteristics	Owns a TV set with antenna. Within range of station to receive viewable picture.	Willing to pay extra for desirable programming (entertainment, sports, or education).	Willing to pay for good picture.	Need willingness to pay for added services from two way operation.	Willingness to pay for sports events and first run movies. Entertainment.
	Urban Suburban Rural	Area covered by TV transmitter dependent on antenna height, power and terrain.	Only one or two systems implemented.	Original usage in small communities with poor OTA reception. New expansion into major markets.	Experiments under way.	Experiments under way. A few systems in operation.

TABLE 7-29

(continued)

	CRITERIA	PAY TV FRAME STORAGE	VIDEO TAPE	VIDEO DISC	OTA FRAME STORAGE	SATELLITE
PEOPLE	Number of people served	Utilization in Pay TV systems- Motel Hotel. Eventual utilization on CATV.	The high cost of players and tapes will restrict utilization in home.	Available after 1975 in USA. Low cost discs and player key to mass usage.	No service presently available.	Potential interface to all forms of OTA TV broadcasting and cable systems.
	Characteristics of community	Experiments under way such as in Reston, Virginia.	Because of cost of video tape and players, use restricted to affluent and commercial. Used for presentations to groups.	Mass distribution, similar to LP audio record, to all areas.	Recipient must be within area coverage of OTA station or cable systems carrying the OTA signal.	Location of ground station to serve geographic regions and population centers.
	User characteristics	Desire for additional services and information via the home TV receiver. Willingness to pay.	Members of various groups, industries, professionals, educators, etc.	Mass distribution to public and special groups. Similar to LP record users.	Desire for ITV services. Middle income groups. High school and high school graduates.	The individual consumer is interfaced to satellite links by terrestrial systems.
	Urban Suburban Rural	Initial implementations in systems of over 2500 subscribers.	Video tapes are used for much of the OTA and cable TV programming. Individual use requires video tape player.	Distribution to all areas as can be similar to LP audio records e.g., Sam Goodys or record (disc) club, etc. if price is right and players in the $100-$200 range.	All areas in range of TV stations signed can receive with special home terminal.	Can serve any area by terrestrial system interconnects to ground station.

TABLE 7-29

(continued)

	CRITERIA	CCTV	MATV	ITFS	INFORMATION RETRIEVAL SYSTEMS	CAI (TICCIT-PLATO)
PEOPLE	Number of people served	Closed system--not mass market oriented.	Usually services apt. houses, hotel/motels, etc.	Distribution of 4 channels to schools and educational institutions.	First application in Info channel on motel/hotel systems.	Students, school systems--not a commercial product yet.
	Characteristics of community	Use not community oriented.	High consumer density such as found in large apartment buildings, condominiums, hotels/motels.	Educational.	Urban, suburban will have resources to develop and implement.	Educational.
	User characteristics	Part of a group private/commercial or educational includes schools/school systems, hospitals, police departments, etc.	Poor OTA reception due to location or restrictions on individual antennas.	Student, educator schools and school systems, colleges and universities.	Desire and need for informational service, students, professionals, researchers, educators, etc.	Students in school, adults continuing education. Vocational training.
	Urban Suburban Rural	Use not dependent on area.	Used primarily in urban/suburban areas.	Urban and suburban use. Rural areas, regional schools and school systems, use.	Information concentration in urban areas. Suburban and rural areas will gain access to this info with TV interface.	School or school systems in all areas with adequate resources.

TABLE 7-29

(continued)

	CRITERIA	OTA UHF TV	OTA UHF PAY TV	CATV ONE WAY	CATV TWO WAY	PAY TV (CABLE)
HARDWARE	System Components and Compatibility	Uses Home TV Receiver	Pay TV Terminal Required and Keycard Use Home TV Receiver	Set Top Converter and/or A-B Switch plus cable connection required. Home TV receiver	Home Terminal & Home TV Receiver Required	Home terminal Key Card & Home Billing required Home TV Receiver
	Flexibility & Variety of Application	One Way only Color or B & W (C, B&W)	One Way only C, B&W	One Way Systems can be modified for 2-way New Systems being constructed have 2-way capability. C, B&W	High degree of flexibility - One-way Two-way monitoring & addition services including demand programming, CAI, etc.	Moderate flexibility can include variety of programming, 2-way interaction, & demand programming
	Channel Availability	One Channel per Station	One Channel per Station - One Station per area	Multi channels available	Multi channels available	Multi channels available
	Hardware Availability	Catalogue Item →	→	→	→	Some OTS hdwe available. Some hdwe in development Experiment system in operation

TABLE 7-29

(continued)

	CRITERIA	PAY TV FRAME STORAGE	VIDEO TAPE	VIDEO DISC	OTA FRAME STORAGE	SATELLITE
HARDWARE	System Components and Compatibility	Home Terminal with Video Refresh Memory	Taping System not Necessarily Compatible. Player to be Used Must Match Recording System.	Video Disc Player Must Match Disc Technique of Manufacturer. No Player Pickup Standardization.	Can only be Used with Typical Home Receiver with Appropriate In-Home Terminal	Ground Station Interface Required to Terrestrial Systems
	Flexibility & Variety of Application	Provide Slide by Slide or Panel by Panel Programming. Can be on Demand Basis or Scheduled. 30-60 Slides/Sec.	Continuous Color or B&W Presentation. Individual Frame Viewing. Frame by Frame Forward or Reverse.	Continuous Color or B&W into 60 Minutes Playing Time per Side. Frame by Frame Advance or Reverse.	Provide Slide by Slide Programming with One Slide per Channel Every Ten Seconds up to 300 Channels Simultaneously	Satellite can Provide National Distribution of TV Channel from Planned Ground Station
	Channel Availability	Not Applicable	1 Channel/Tape	1 Channel/Disc	100 to 300 or More, w/wo Demand Programming or Audio	Depends on How Many Satellites & Transponders/Satellite
	Hardware Availability	Some OTS Hardware Available. Development of Low Cost VRM Key Component	Catalog Item	In Development. Available Commercially 1975 on.	No Commercial Development Known ITV/Other	A Number of Proposals to FCC have Plans for Satellite System. 600 Plus Transponder will be Available if all Proposals Go Ahead.

TABLE 7-29

(continued)

	CRITERIA	CCTV	MATV	ITFS	INFORMATION RETRIEVAL SYSTEMS	CAI (TICCIT-PLATO)
HARDWARE	System Components and Compatibility	Equipment Frequently Low Cost--Incompatible with Other TV Uses	Home TV Receiver is Used for Audio Video Output	Uses Microwave Equipment for Transmission. Not Compatible with Home TV Receiver. Special Receiving Equipment Required	Resolution of Home TV Receiver Poor for this Application Special Techniques Required	Specialized Systems
	Flexibility & Variety of Application	Usually One Channel Per Cable C, B&W	OTA Channels Plus Added Channel for Individual Systems C, B&W	Limited to 4 Channels/System Special Receiving Installation Required	Microfilm & Microfiche Handled most easily with Existing System. Information Banks & Libraries must be Set Up for Information Retrieval Use	Flexibility Provided by Computer and Software
	Channel Availability	One Channel (Usual) Multichannel Possible	Multichannels Available	4 Channels Available	Not Applicable	Not Applicable
	Hardware Availability	Catalog Item →	→	→	In Development for TV Systems	Prototype Hardware in Use

TABLE 7-29

(continued)

	CRITERIA	OTA UHF TV	OTA UHF PAY TV	CATV ONE WAY	CATV TWO WAY	PAY TV (CABLE)
ECONOMIC	Economic Viability	Yes for Commercial Stations	Yet to be Proved	Proved in Many Areas Large Amount of Front-End Moneys Urban Areas with Underground Installation?	Yet to be Proved	Where Installed, such as Teleprompter System in NYC, it is Viable
	Private Sector Participation	Major	Major	Major	Major	Major
	Growth Without HEW Participation	Yes (Existing) Added UHF ITV Stations Support Required	If ITV Service to be Provided, HEW Participation Required	System Growth in Size & Quantity will occur without HEW ITV Use will probably Require HEW Support	FCC Capability Requirement for New Systems	Low Cost VRM Holding Back Service--Plus Suitable Data Banks & Programming
	Initial User Investment	Buy TV Set & Installation	Buys Minimum/Month or Pay Terminal Removed	Pays for Installation Pays Monthly Connection Fee	Pays for Added Services Monthly	Pays for Pay TV Capability/Month or Pays per Program Viewed
	Users' Fees	Free	Pay/Program Pay/Month	None	None Except for Additional Service	Yes--by Program By Subscription

TABLE 7-29

(continued)

	CRITERIA	PAY TV FRAME STORAGE	VIDEO TAPE	VIDEO DISC	OTA FRAME STORAGE	SATELLITE
ECONOMIC	Economic Viability	In Pay TV MATV System Advertiser Supported Other Applications?	Yes	To be Proven	To be Proven	Yes
	Private Sector Participation	High Info with Advertising ITV--Low (Non-Existent)	Major	Major	No Present Support	Major
	Growth Without HEW Participation	Low Cost VRM Holding Back Service Plus Suitable Data Banks & Programming	Yes	Yes. Development & Use Disc for Entertainment, e.g. LP Records	No Known Development of OTA Frame Storage Channel HEW Support Needed	Initial Support by HEW May be Required
	Initial User Investment	Pay for Service Monthly or by Service Used	Buys or Rents Player Buys or Rents Taped Programs	Buys or Rents Player Buys or Rents Discs (Disc of Month Club, etc.)	Undetermined	Not a Direct Cost
	Users' Fees	ITV--Yes	Yes	Yes	Yes	None

TABLE 7-29

(continued)

	CRITERIA	CCTV	MATV	ITFS	INFORMATION RETRIEVAL SYSTEMS	CAI (TICCIT-PLATO)
ECONOMIC	Economic Viability	Yes, Viable	Yes, Viable	Public Support	To be Proven	To be Proven Much Depends on Using Maximum Number Terminals for Maximum Hours
	Private Sector Participation	In Schools--Public Support by Various Levels of Gov't	Major	Public Support	Major	Gov't/Public Support
	Growth Without HEW Participation	CCTV in School will Continue to Need Public Support to Maintain Growth	No HEW Participation Needed for Growth	Continued Public Support Required	Present Developments for Automated Information Systems not TV Oriented	Being Supported by HEW Presently
	Initial User Investment	Pay for System Installation & Operational Costs	May be Included in Rent or Room Charges (Maintenance Fees in Condominiums)	Public Support	Pays for Service Used	Part of Tuition Costs Where Used
	Users' Fees	None	OTA Channel Free after Monthly Conn. Charge Pay TV by Program	None	Yes	Yes

TABLE 7-29

(continued)

	CRITERIA	OTA UHF TV	OTA UHF PAY TV	CATV ONE WAY	CATV TWO WAY	PAY TV (CABLE)
SOURCES	Dissemination	One Way Conventional Broadcasts to Receivers	One Way, Scrambled Broadcast to subscribers with decoders	One Way to all users connected to the cable system	One Way & Interactive, a number of experimental systems being tried in field	One Way, Monitoring & Interactive just starting to be implemented
	Continuous Films, Tape & Live	Source interfaced by present stations	Most presentations or film and tape special events and sports presented live	OTA, programming provided uses these sources	Most presentation film or tape. Live also.	Most presentation film or tape special events and sports also live
	Panel By Panel, or Slide by Slide Multi-Presentation	Slide by slide or panel by panel provided no simultaneous multi presentation	→	No--Unless Home Terminal Includes VRM & Frame Selection	No--Unless Home Terminal Includes VRM & Frame Selection	No Multi presentations without frame storage
	Consumer Demand Programming	No direct interface to station to select program you want at a particular time	No →	No →	Yes, with interactive cable systems demand programming can be provided	Can be provided, however not in today's systems. Experiment underway

TABLE 7-29

(continued)

	CRITERIA	PAY TV FRAME STORAGE	VIDEO TAPE	VIDEO DISC	OTA FRAME STORAGE	SATELLITE
SOURCES	Dissemination	One Way & Monitoring or Interactive	Taped material presented by one way systems e.g. Video tape player and TV set or OTA or Cable Broadcast	Low cost player should result in home use. Presentation one way, no interaction	One Way, by over the air broadcast to suitably equipped subscriber	One Way--Major 2 Way--Minimal both data and TV
	Continuous Films, Tape & Live	Not an efficient mode for this media	Films are easily converted to tape. Most programming taped for showing rather than live	Film and master tapes are a source of program material live converted to tape than to disc	Not an efficent mode for media	Yes, satellite will accept TV channel regardless of program source
	Panel By Panel, or Slide by Slide Multi-Presentation	This is the mode of presentation by this system	Yes, it may provide the storage and playback of this type programming	→	This is the mode of presentation by by this system	Yes, satellite will accept TV channel regardless of programming
	Consumer Demand Programming	Yes, existing systems can and do provide on a limited basis	This will probably not be a source because of player and tape costs	Yes, the consumer may go out and buy when he wants and also view it when he wants	Not likely to be implemented but is possible	Possible future satellites may provide sufficient channels and 2 way operation required

TABLE 7-29

(continued)

	CRITERIA	CCTV	MATV	ITFS	INFORMATION RETRIEVAL SYSTEMS	CAI (TICCIT-PLATO)
SOURCES	Dissemination	One Channel, One Way (Usually). Cable bandwidth can support multi channel and 2 way operation	One Way OTA Channel Pay TV 2 Way Info Channel 2 Way	One Way with four channels maximum	Two Way. These are futuristic systems for TV system usage	Two Way. TICCIT uses cable. Plato uses telephone lines or a multiplexed cable channel
	Continuous Films, Tape & Live	Yes, this is the conventional source of program material	OTA programming carried on system. Added channels can include all of these sources	These are usual programming source for these systems	The sources can be included in the information to be retrieved	Not the program sources for these systems
	Panel by Panel, or Slide by Slide Multi-Presentation	Capability can be Provided Not Usually Available	In Hotels & Motels Etc. Pay TV Includes Information Channel	No Unless School Terminals Equipped with VRM, Etc. No Known Usage Now	Yes--Major Mode of information retrieval for user	Computer generated Information and interaction displayed in this manner
	Consumer Demand Programming	No provision for this mode of operation usually. It is possible however.	No provisions for this mode of operation may be added via pay TV operation inserted into the MATV cable system	No provisions for this mode of operation	Yes, consumer may call information he individually desires	Yes, this is a part of their interactive provisions.

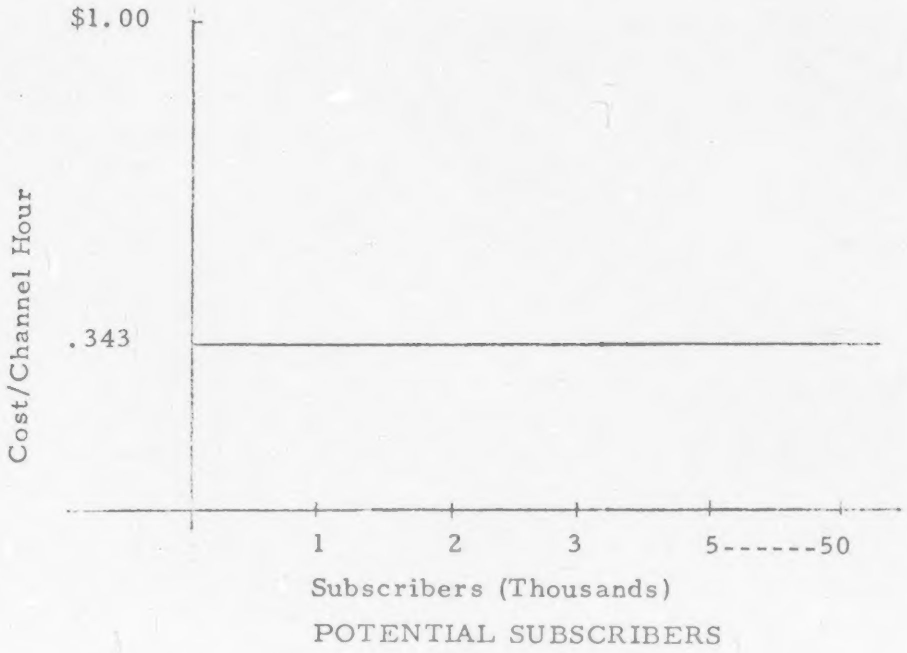
7.6.1 Examples

The example analyses shown are for CATV, Pay TV, OTA UHF broadcast, and video disc. The data for the graphs is obtained from Section 7.4 of this report. In this analysis we will define a number of constants between the system comparisons so as to provide an apples-to-apples comparison rather than an apples-to-oranges comparison. We will also take the cumulative present value of annual costs based on a 10% discount rate and a period of 10 years. Generally we will neglect such inflationary factors as hardware cost trends and labor rate increases in determining present value.

Example 1

First let us consider the case of adding an OTA UHF TV channel to a CATV system. We shall also assume that there are eight hours of programming time per day for 364 days for a total of 2912 hours per year. Extrapolating from the data in Table 7-13, the cost per channel hour can be calculated to be a constant 34.3¢ based on a time span of 10 years. Figure 7-27 reflects this. Let us remember that this is a channel being added to an existing system, whatever its size. We have also assumed that adding the channel does not result in any increase or decrease in the number of subscribers to the existing system. The system operator does not have to supply any programming, since he is merely redistributing onto the cable what he receives from the OTA station. The plot of Figure 7-28 shows the costs per channel hour per subscriber for various system sizes from 1000 to 100,000 subscribers. These costs are extremely low and are only those for the added channel. An example of this mode could be the addition of a station--educational or commercial--that the CATV operator wanted in the system. We have shown, therefore, the price to be paid for reaching a larger potential viewing audience, and we have also demonstrated that the cost per channel hour does not vary with the number of subscribers. It is obvious, moreover, that without doing a specific market analysis of a particular program's acceptability, we cannot obtain all the inputs required to complete a comparison.

Figure 7-27 CATV Costs per Channel Hour
For an Added Over-The-Air Channel



Notes:

1. Non-Recurring Cost = $3,593.0

2. Cumulative Present Value of Recurring Costs (900 x 6.77) ($1800 per/16 hr. day) = $6,093.

3. Number of hours per year- 2912 hrs/yr. for ten years is 29,120 hours

4. Notes of Table 7-13 also apply

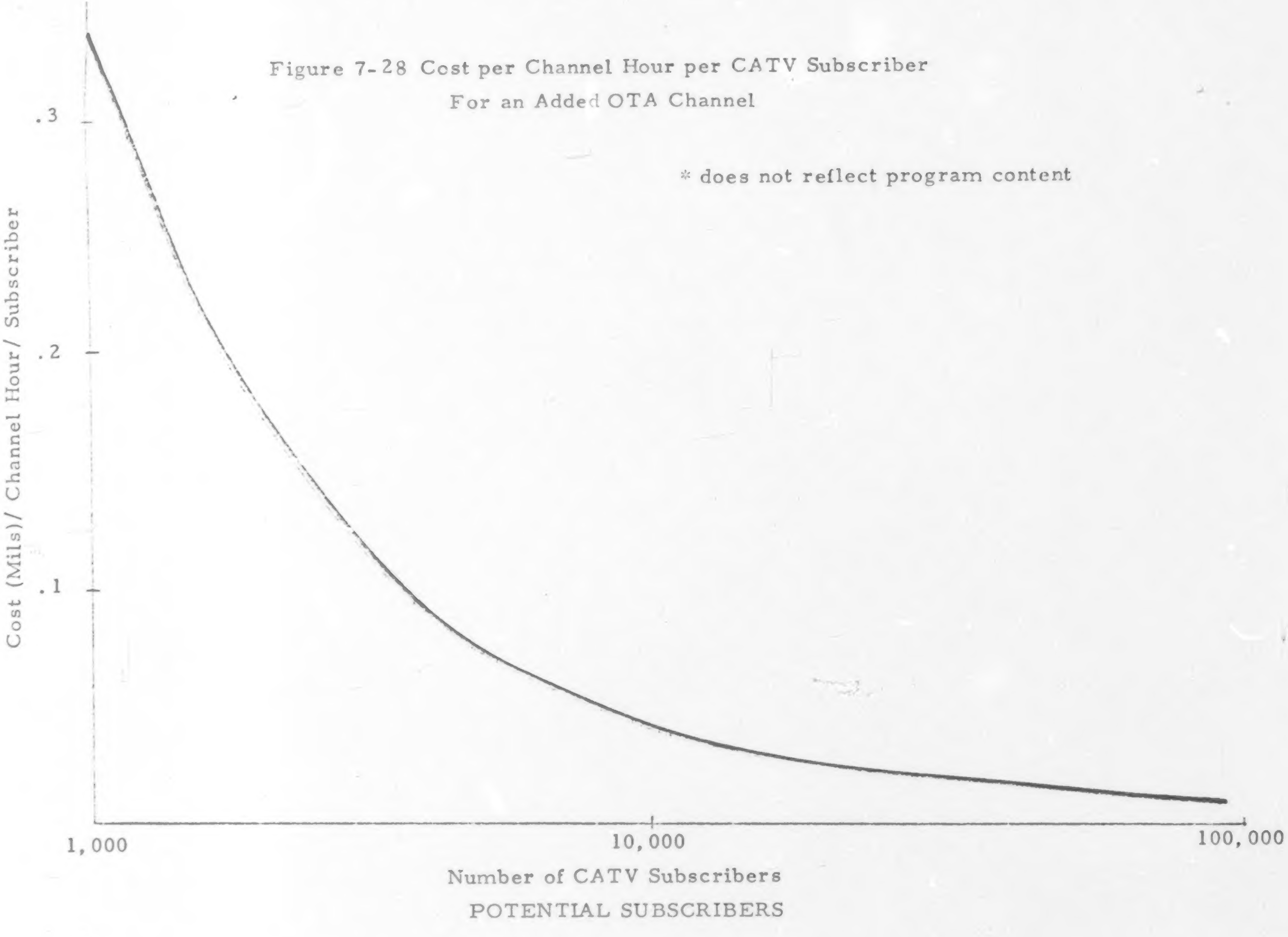


Figure 7-28 Cost per Channel Hour per CATV Subscriber
For an Added OTA Channel

* does not reflect program content

Example 2

In this example we will assume that the CATV operator wishes to add ITV programming to a channel that he locally originates with a video taped program material. We have assumed the addition of the tape player equipment, the programming required and the modulator to take the audio and video signals from the tape players and provide it to the cable. The costs to add such a channel are shown in Table 7-14 . The cost, using the present value of recurring costs, is $646 thousand; the hours of programming over a ten year period are 29,120 hours.

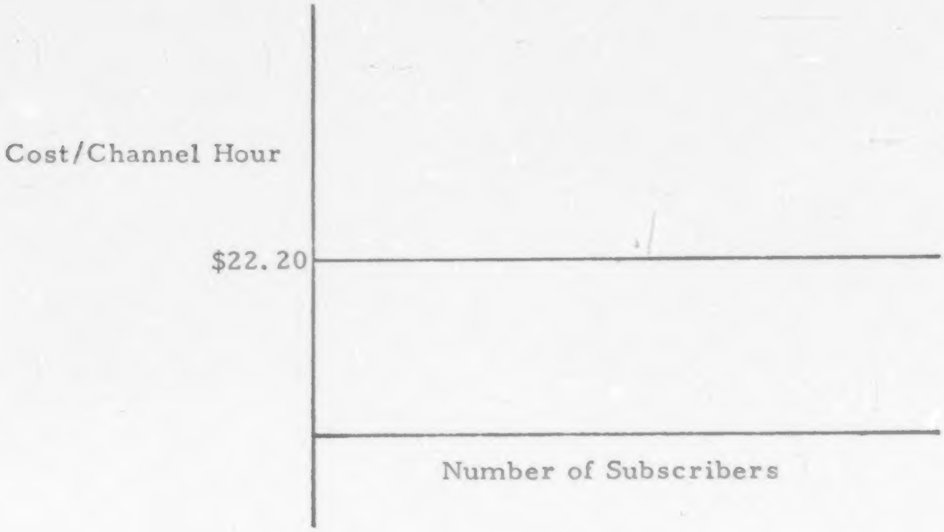


Figure 7-29 Cost/Channel hour for added Tape Programmed Channel

Figure 7-29 shows the Cost/per channel hour for the added channel of taped programming. Again this is an addition to an existing CATV system with capacity for added channel throughout the system so that only additions to the local origination equipment is required. The system is assumed to neither gain subscribers nor lose subscribers by the addition of the channel. Again a period of ten years is chosen for the analysis and a 10% discount used in determining the present value of annual costs for wages and programming. This example is essentially applicable to Pay TV or CATV for the addition of ITV taped programming. However, the penetration of Pay TV systems is usually only 20-30% of the CATV subscribers. Figure 7-30 represents the cost per channel hour per CATV subscriber.

Figure 7-31 represents the cost per channel hour per Pay TV subscriber. Again these cost curves can be looked at as the price HEW would have to pay for using a specific distribution system in reaching a certain viewing audience.

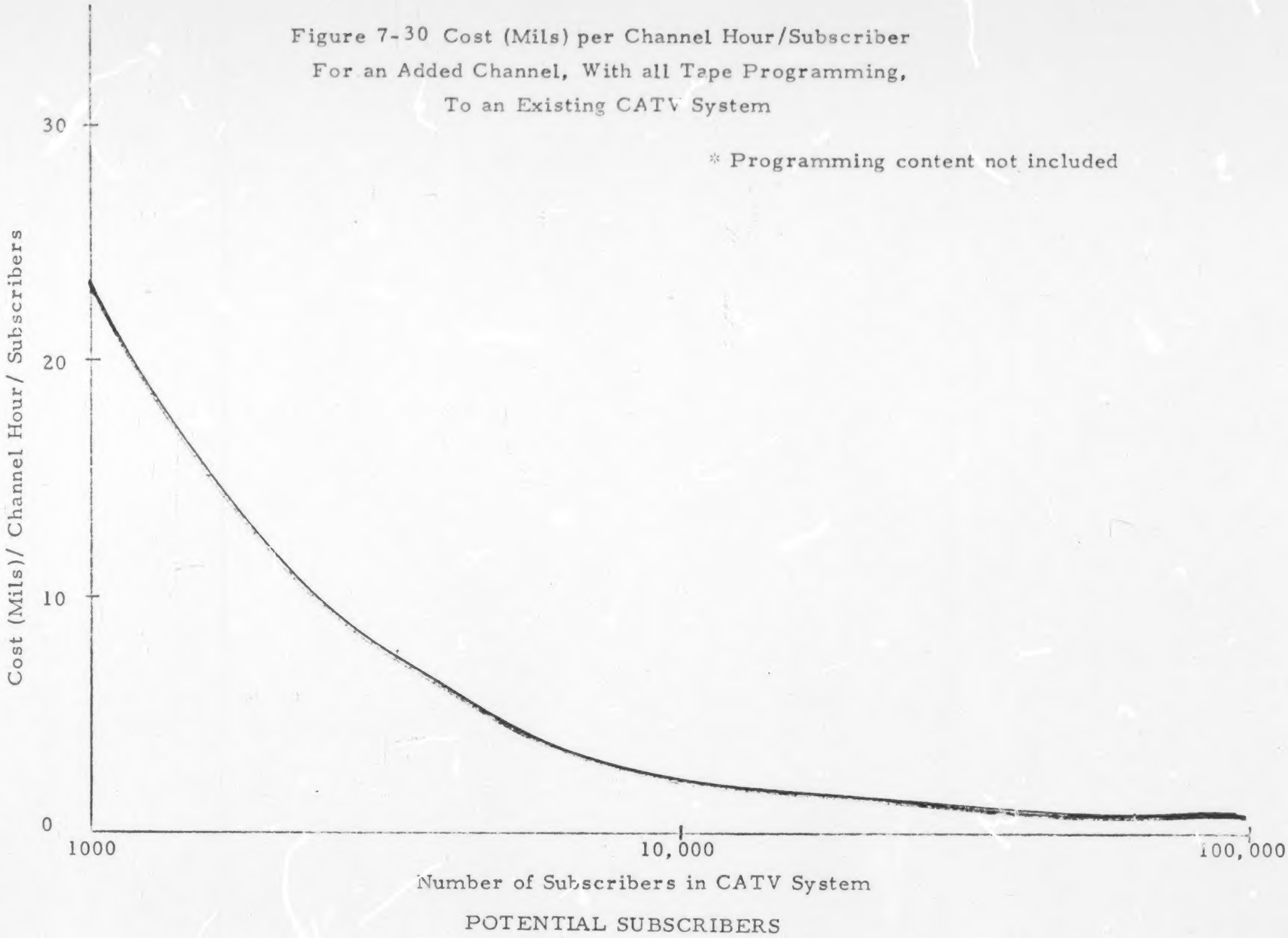


Figure 7-30 Cost (Mils) per Channel Hour/Subscriber
For an Added Channel, With all Tape Programming,
To an Existing CATV System

* Programming content not included

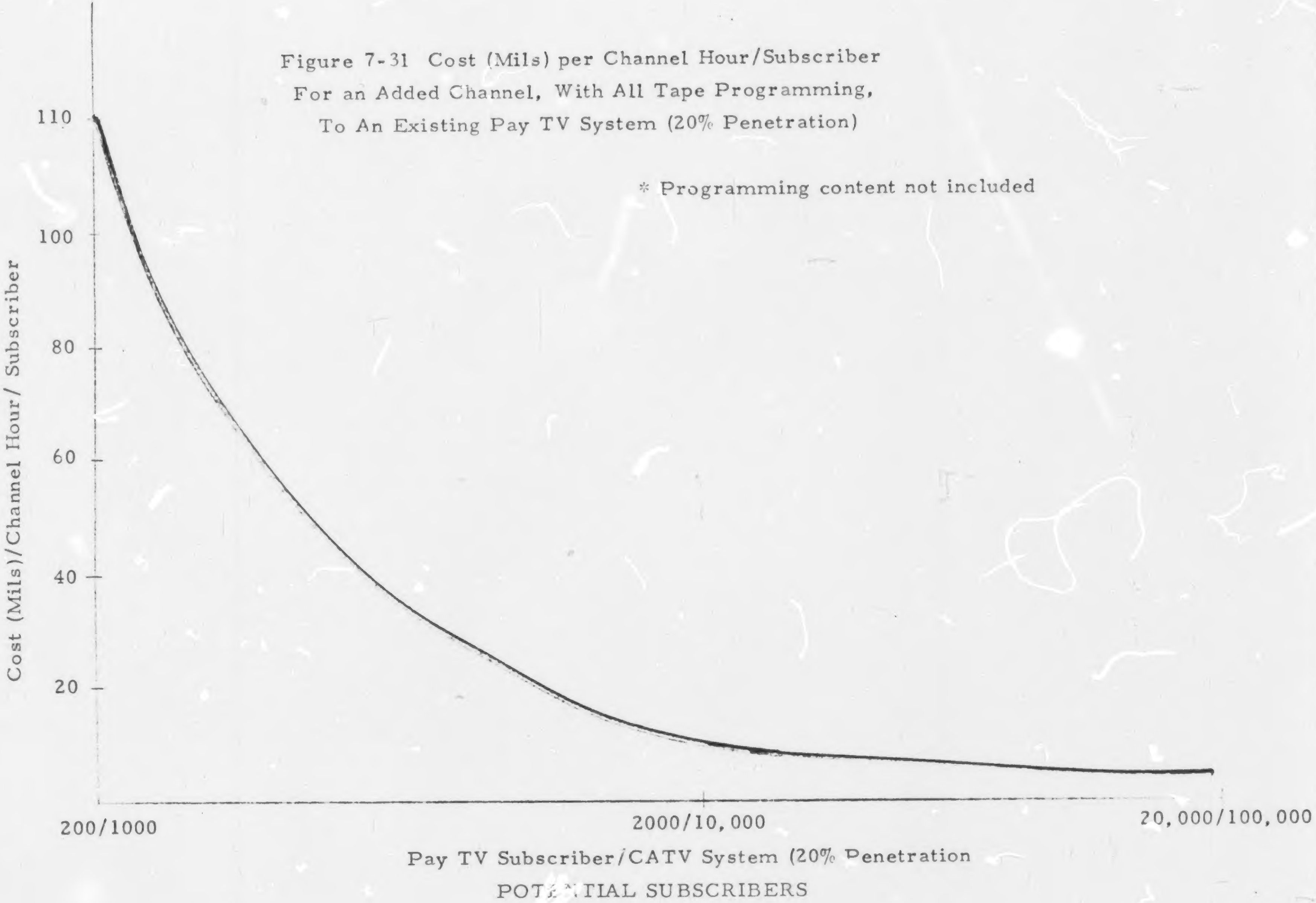


Figure 7-31 Cost (Mils) per Channel Hour/Subscriber For an Added Channel, With All Tape Programming, To An Existing Pay TV System (20% Penetration)

* Programming content not included

Example 3

In this example we are going to present video disc costs based on Table 7-19 and relate this to a cost per channel hour. The curve is smoothed to represent the quantities shown in the table. The curve in Figure 7-32 shows that as the number of subscribers increases the cost per disc subscriber decreases in a non-linear fashion, as shown. In addition we want to add in the video player cost. For our purposes we will assume that the price of the player is $200 based on the goals for quantities produced for entertainment use. Further, we will assume the useful life of the player as 10 years at $20 per head based on a straight line depreciation. Further, we will assume that the video player owner has 50 hours of playing time per year as an average and therefore that this video player is a fixed cost of 40 cents per channel hour per subscriber as shown in Figure 7-32.

Figure 7-32 is a representation of the total dollars per channel hour for various quantities of discs for actual subscribers. It also represents costs per channel hour. An important contribution to this cost is the promotion and packaging costs which are estimated. A real figure would have to be based on a market analysis. Even with the promotion shown, the cost per channel hour per subscriber in Figure 7-32 is only $4.00 for 100,000 subscribers. At this point, several significant points should be made:

1. A disc can be considered as one channel that is available at any time for any fraction of viewing time.
2. The number of programs capable of being viewed can be very large.
3. The facilitation costs of the player and the manufacturing facility is borne by the entertainment industry.
4. We distinguish between the curve presentation of the disc and the curve representation of the other systems, for the disc curve represents actual subscribers who have purchased the disc for

viewing, as compared to the potential subscribers reachable by the other distribution systems.

5. We have also assumed in the disc case that the disc manufacturer paid for its original programming and the promotion of the programming. These costs are not reflected in the other estimates. This is established in Figure 7-33.
6. It should be noted that the disc provides a source of revenue and is not limited to a specific subscriber industry such as CATV.

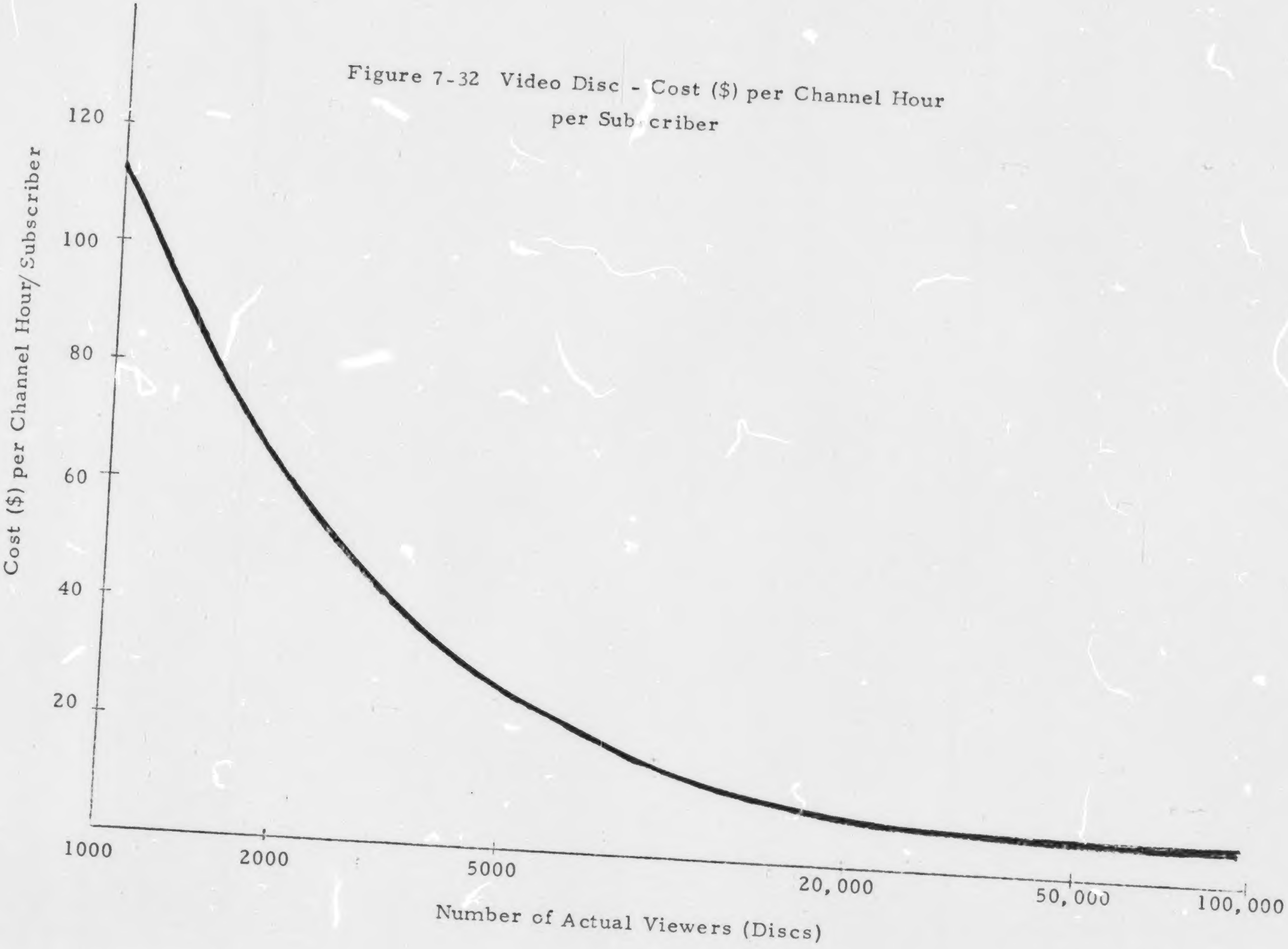
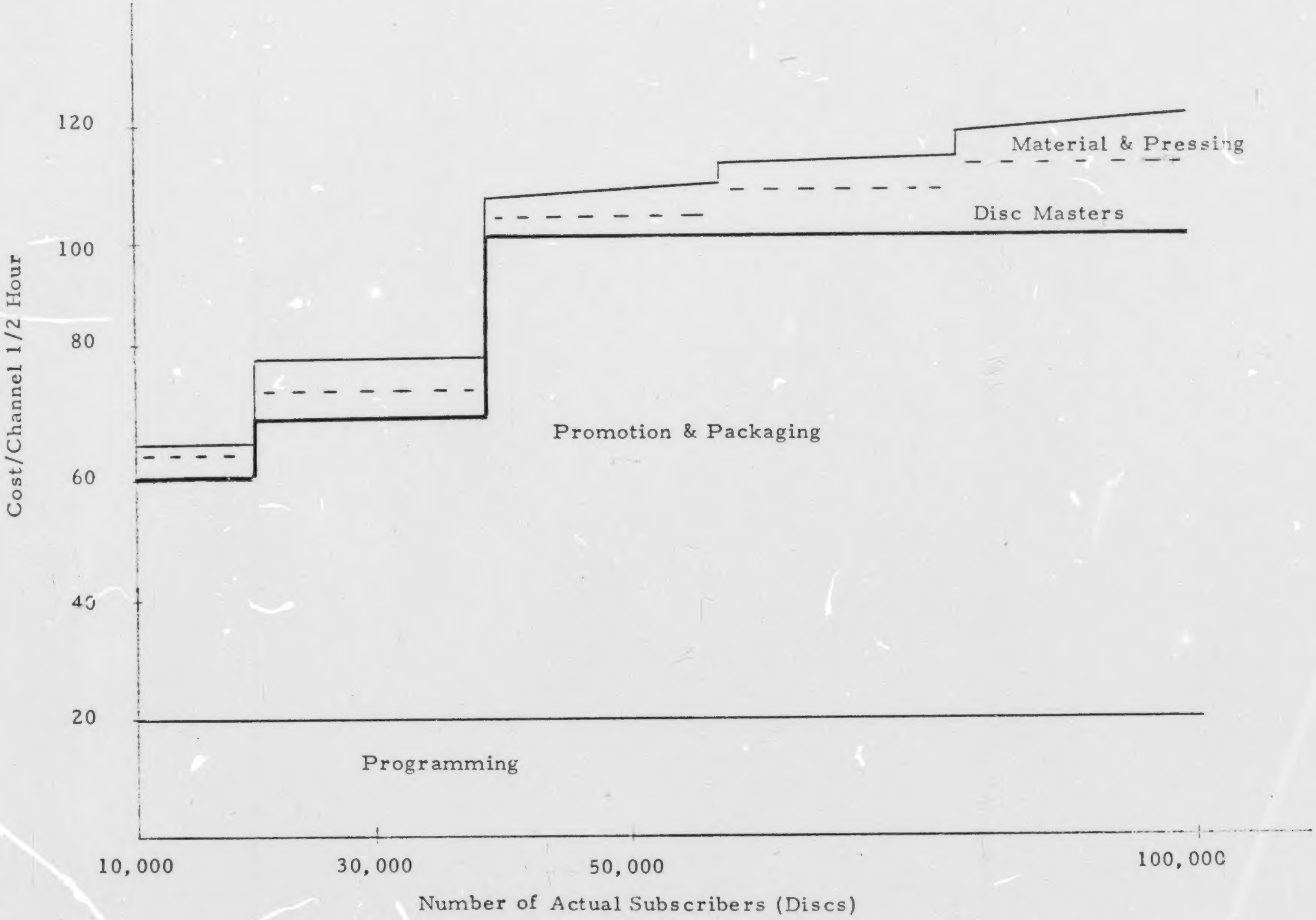


Figure 7-32 Video Disc - Cost ($) per Channel Hour per Subscriber

Figure 7-33 Total Cost per Channel 1/2 Hour for Video Disc



Example 4

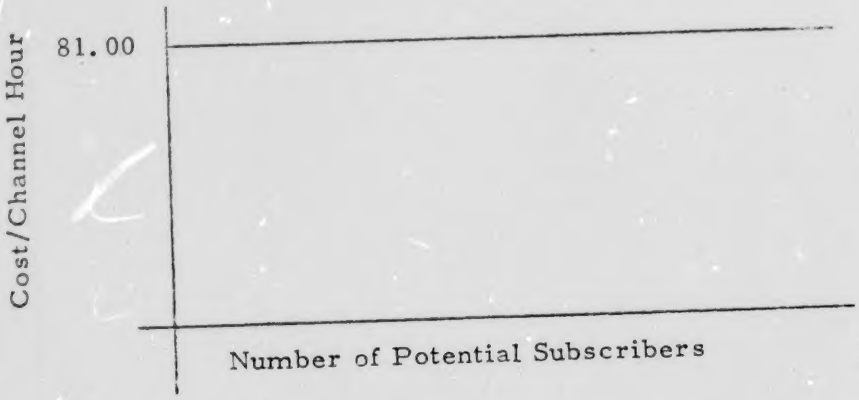
To add an OTA UHF channel requires a new TV station. In this example we are going to analyze this station in the way we analyzed the previous examples, to arrive at a cost per channel hour per subscriber. We are going to do this for a station with a radius of coverage of 30 miles and use the information presented earlier in Tables 7-21, 7-22, 7-23, and 7-24.

$ 69,000	Tower
82,500	Tx and Antenna
103,700	Other Station Costs

Since the added channel is presumed to be an ITV channel we will operate with a minimum studio configuration. It is presumed that the majority of programming to be used will be video tape and that a budget of $150,000 will suffice. If a more elaborate studio is required it will be shared with other users to keep costs down. This provides us then with a station for $404,000 dollars.

To provide a comparable analysis to example 1 shown previously, we will limit the station to 8 hours of broadcasting per day. Program costs similarly will be kept to $176,000 the first year and $76,000 each year thereafter. We have assumed that ITV programs will be repeated in subsequent years if they are acceptable to the viewing audience. The OTA analysis shown previously had 16 hours of programming. The audience (number of potential subscribers) depends on the number of homes per square mile. A thirty mile radius will encompass 2800 square miles. In a city or suburban area such as the metropolitan area in and around Baltimore there are over 2 million people and over 500,000 thousand homes within a 2500 square mile area. Although the cost per channel hour is high (see Figure 7-34), the cost per channel hour per potential home subscriber (see Figure 7-35) becomes very low as the number of subscribers increases. Thus the cost per channel hour per potential home subscriber is dependent on the population density of the area served.

Figure 7-34 Cost per Channel Hour For an OTA UHF Channel With 30 Mile Broadcasting Radius



Notes:

1. Annual Costs for this example

a. Wages and Salaries, Maintenance and Insurance	$200,000/year
Present Value	$1,354,000
b. Programming @ 120/hr tape	$156,000 first year $ 78,000 each succeeding year
Present Value	$590,000
c. Programming hours/yr including repeats	2912

2. Non-recurring cost for station $404,000

Figure 7-35 Cost per Channel Hour per Subscriber

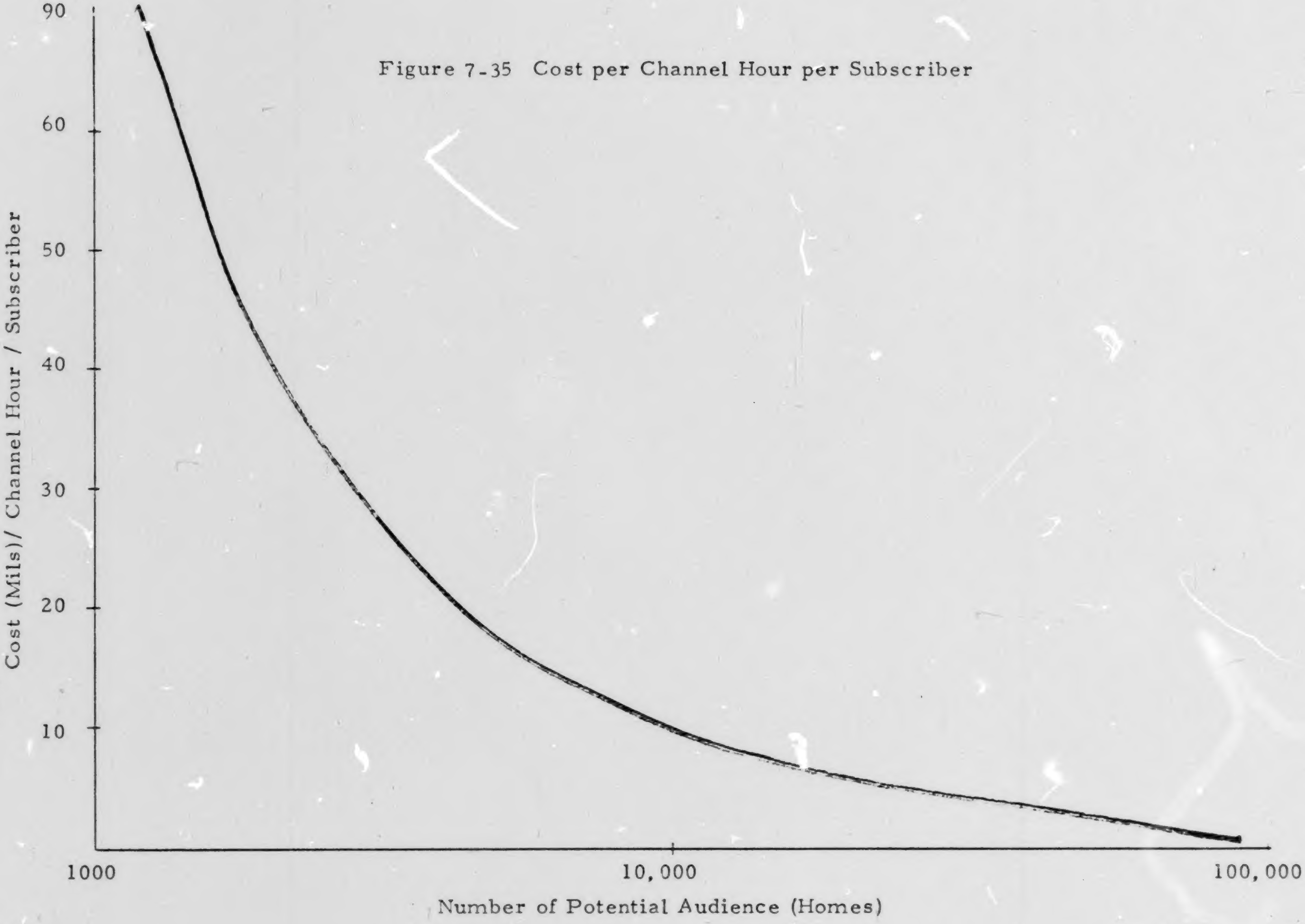
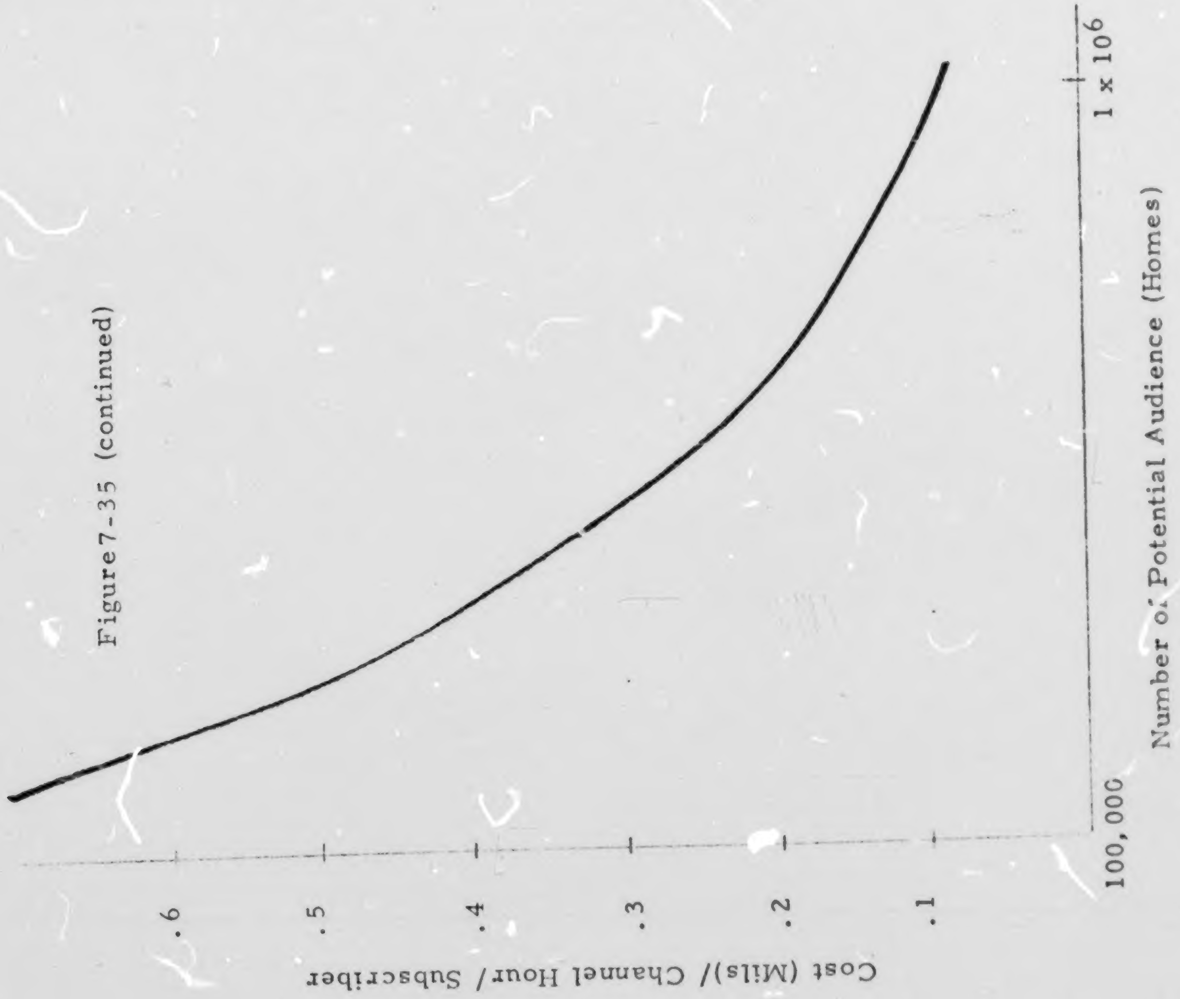


Figure 7-35 (continued)



7.6.2 Summary

In each of the examples of 7.6.1 we have presented two curves; the first is the cost per channel hour versus number of subscribers and the second is the cost per channel hour per subscriber versus number or subscribers. These examples and curves represent the costs to add one more channel to an existing system or, in the case of video disc and over-the-air UHF TV, to add a new channel. They provide the capability for making decisions between the various systems.

In comparing the four examples, Figure 7-36 presents in summary the cost per channel hour for each of the examples. Three of the examples have a constant cost regardless of the number of subscribers, and consequently quickly indicate, for the given examples, which choice gives the least cost per channel hour for the type of TV channel added. The video disc costs are more difficult to interpret, since the cost per channel hour varies with the quantity of discs produced. Since it is presumed each disc will be purchased, the cost per channel hour also approximately represents the cost per channel hour per subscriber or purchaser of the disc. Also to be considered in examining the disc example is the use of the disc by more than one person or the repeated plays of the same disc as a part of the learning process by the purchaser.

The summary of costs/channel hour/ subscriber are shown in Figure 7-37. The video disc costs per channel hour per subscriber is not shown by this figure, since the costs did not ever get this low and the reader is referred to Figure 7-32 for video disc. It should be pointed out that video disc costs/channel hour/ subscriber represents actual users of the disc, whereas the curves for examples 1, 2 and 4 represent potential users. A marketing demand analysis would be required to estimate how many of the subscribers would actually be program viewers. Even the added Pay TV channel of example 2, which is based on a penetration of 20% of the CATV-system subscribers, would also be subject to how many of the Pay TV subscribers would actually view the ITV program material.

We also have grouped here Figures 7-38 through 7-41, which present the total costs including recurring and non-recurring charges. These analyses can be used to show the investment that is going to be required for adding a channel both for non-recurring cost and the accumulated present value of the recurring cost. This allows an evaluation at the present time of both costs as a part of the total cost. Also in considering the summary figures of 7-38 through 7-41, the qualitative factors of Figure 7-41 must also be considered in the making of decisions. It may also well be that one system is preferable in certain areas such as CATV in low or moderately dense areas, and another system in other areas, e. g., OTA - UHF TV, may be more suitable for high population density areas of over 500 thousand TV families within a 30 mile radius.

The domestic communications satellites proposed to the FCC has not offered an economical distribution service for the use of CATV systems, schools, or others for ITV programming. The ATS-F, HEW-CPB, satellite experiment may provide the necessary inputs and confirmation to the design and implementation of a satellite system for ITV and educational uses. Needed in particular is a satellite system with low cost ground stations, easily emplaced, and satellite coverage nationwide. Further, multiple channels of sufficient quantity to satisfy ITV needs should be provided. Such a system, however, is years off and a cost detailed analysis and comparison for ITV use only should be prepared when the system requirements and proposed design is established. Numerous previous studies have been conducted on satellite configurations which we feel have been based on technology projections. The real cost issue may involve the investor's interest in providing transponder channels that may not make a profit. Therefore a change in current FCC policy to require true channel availability as is currently applied to cable television may be required.

Figure 7-36 Summary of Cost ($) per Channel Hour

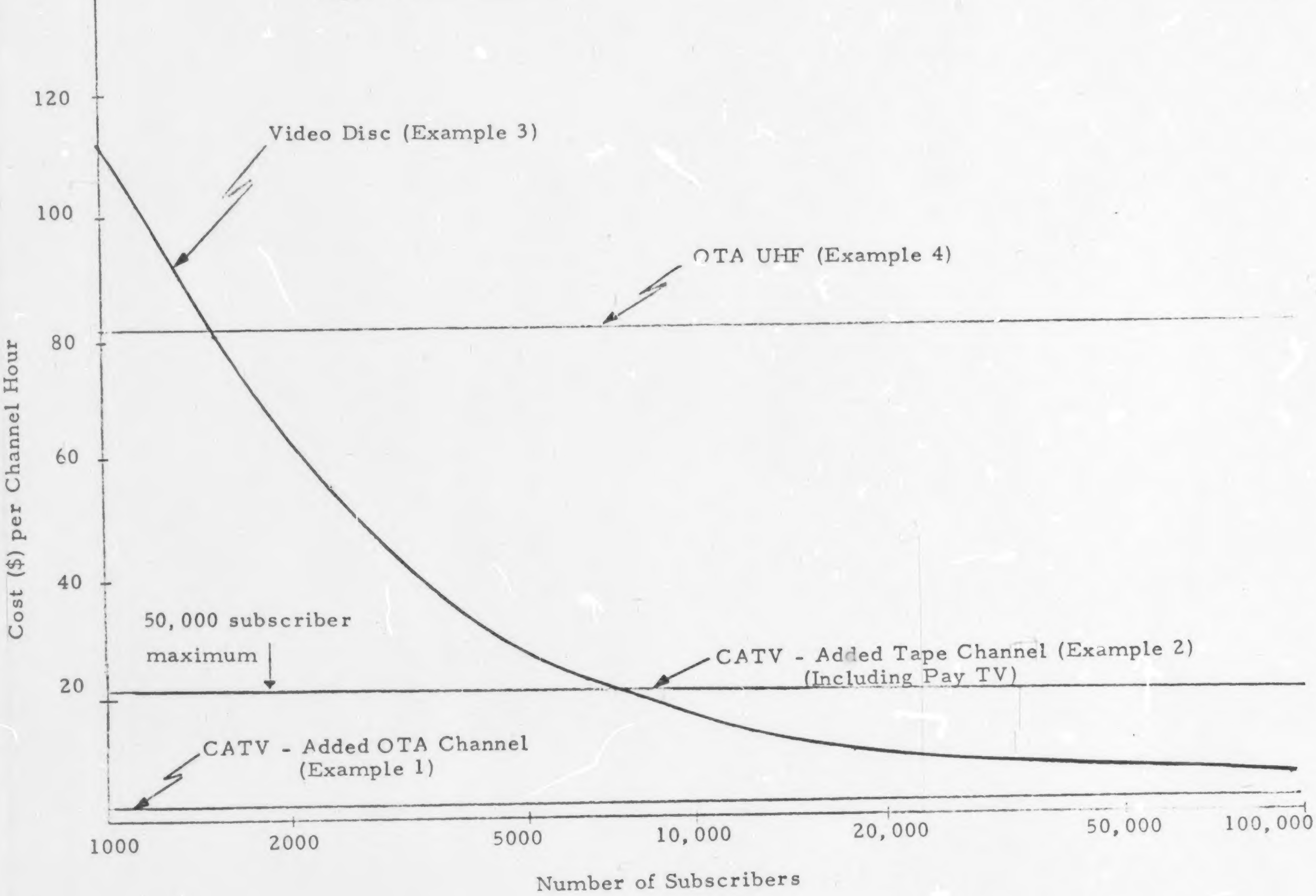


Figure 7-37 Summary of Cost/Channel Hour/Subscriber

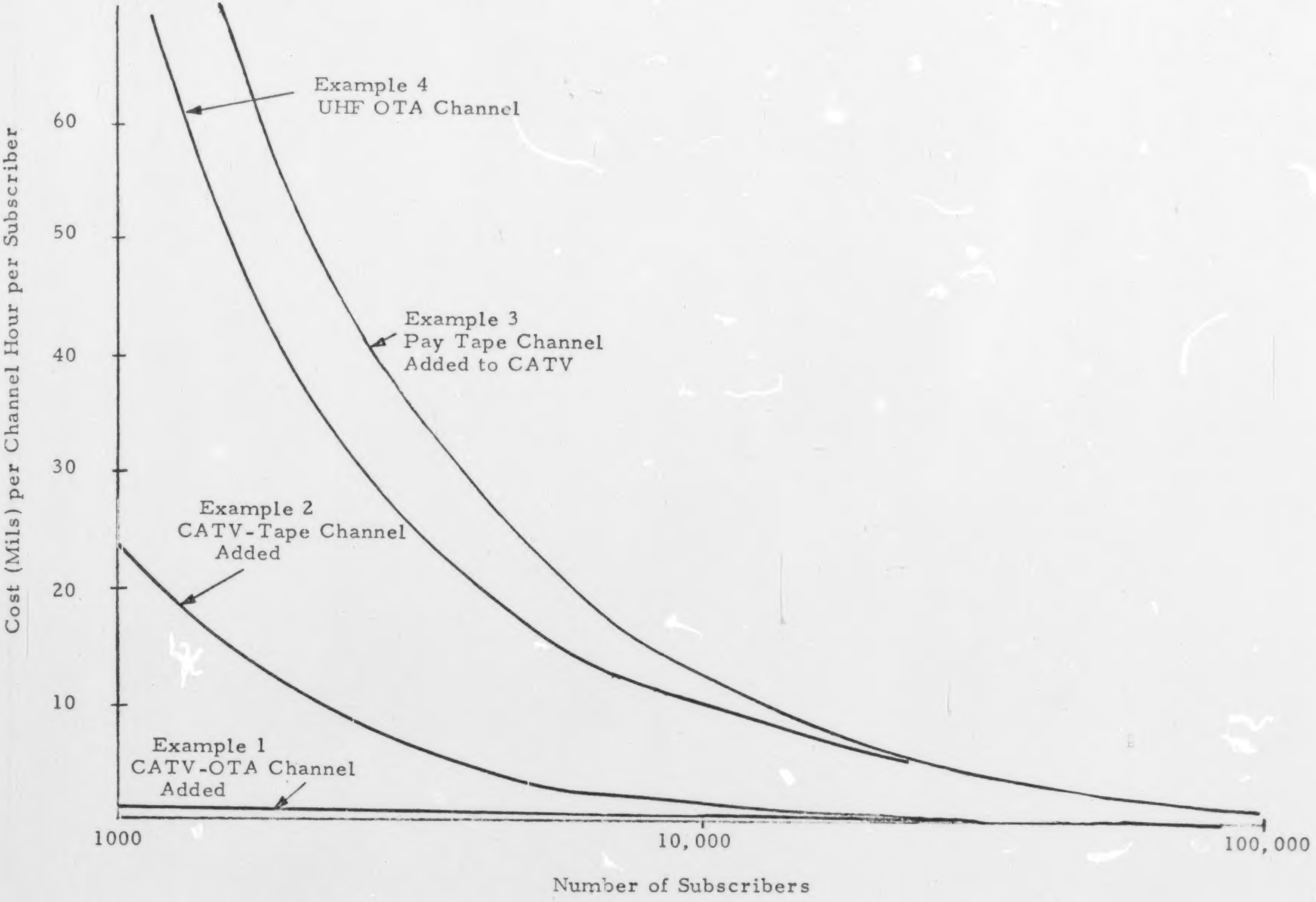
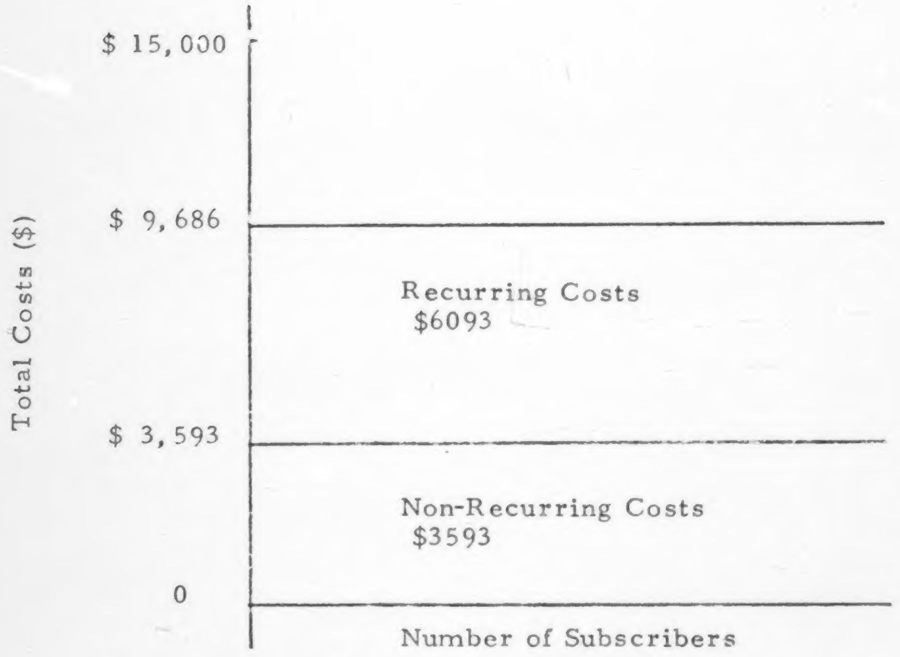


Figure 7-38 Total Costs For Adding OTA Channel To CATV System (Example 1)



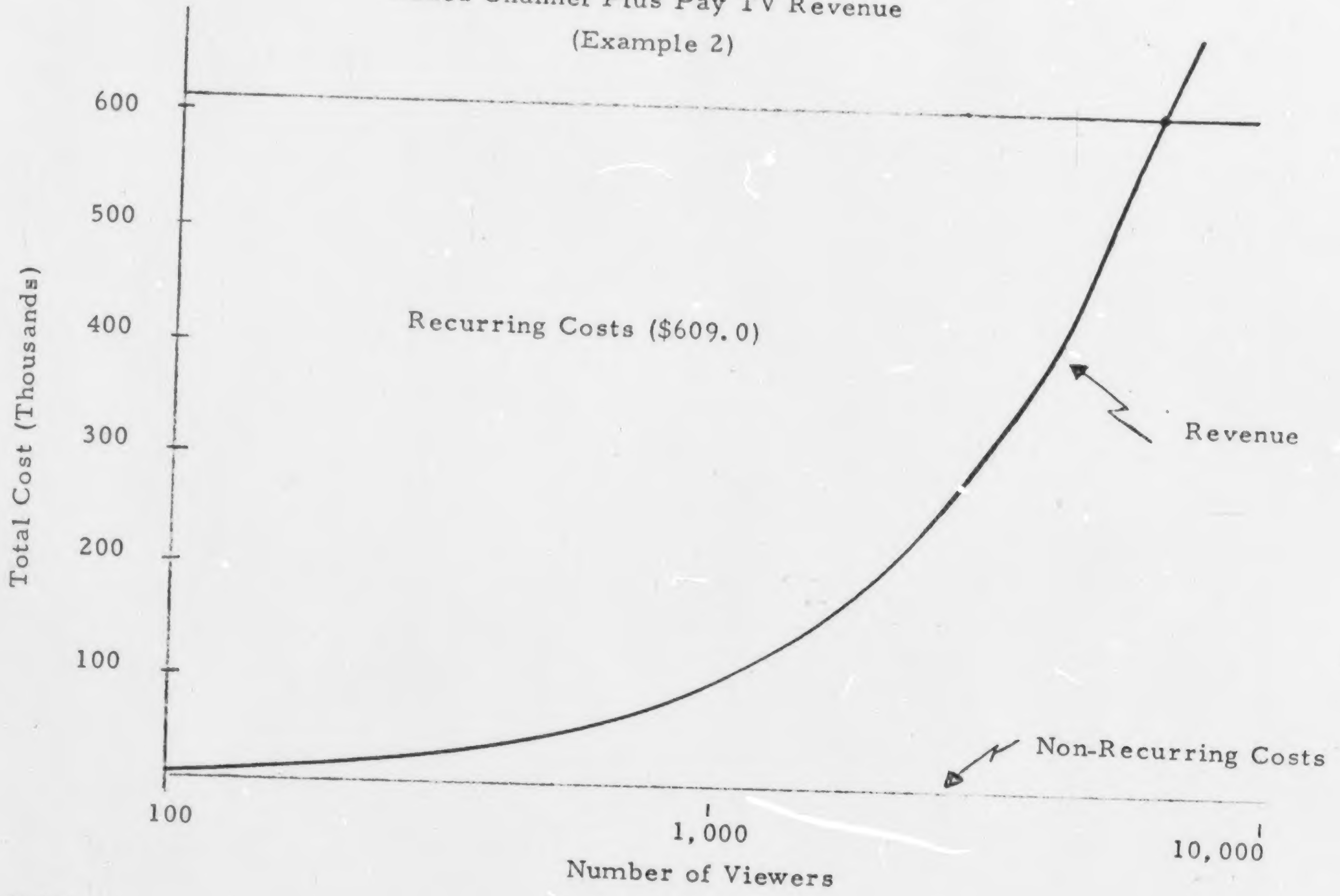
Notes:

1. Recurring Costs represent the accumulated present value of annual costs based on 10 years and 10% discount rate.

2. No revenue is generated.

3. Channel is added to existing system and no change in the number of subscribers is expected as a result.

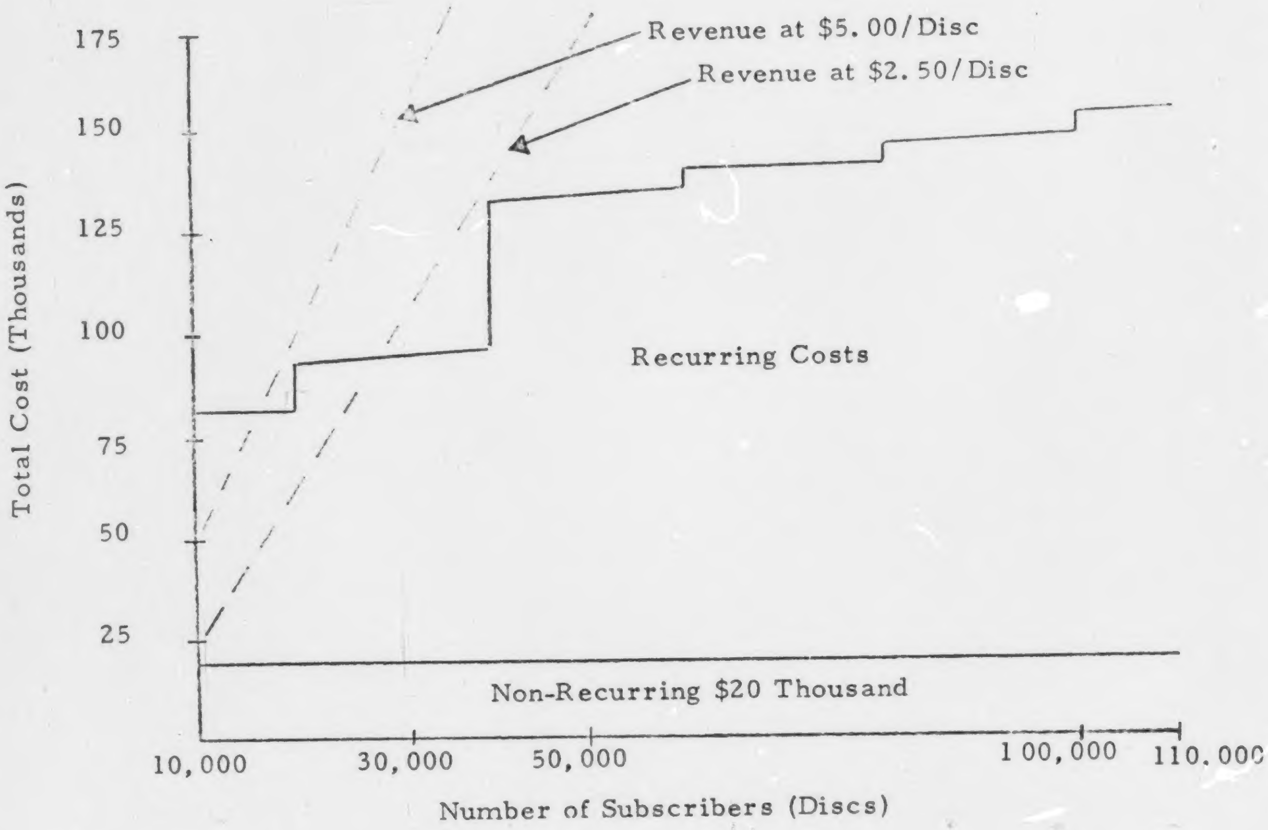
Figure 7-39 Total Costs for CATV or Pay TV Added Channel Plus Pay TV Revenue (Example 2)



Notes:

1. Each viewer watches 74 hours of programming per year and pays 2.00/hr. for $148 revenue/ year per viewer. The accumulated present value of the revenue is $1000.
2. Scale of number of viewers based on largest CATV system is 50,000 subscriber. Pay TV averages between 20-30% of CATV subscribers.
3. These costs and revenues represent an added channel to an existing system.
4. Revenue is shown for Pay TV only. ITV programming is assumed not to carry advertising.
5. Costs are independent of number of viewers/subscribers.

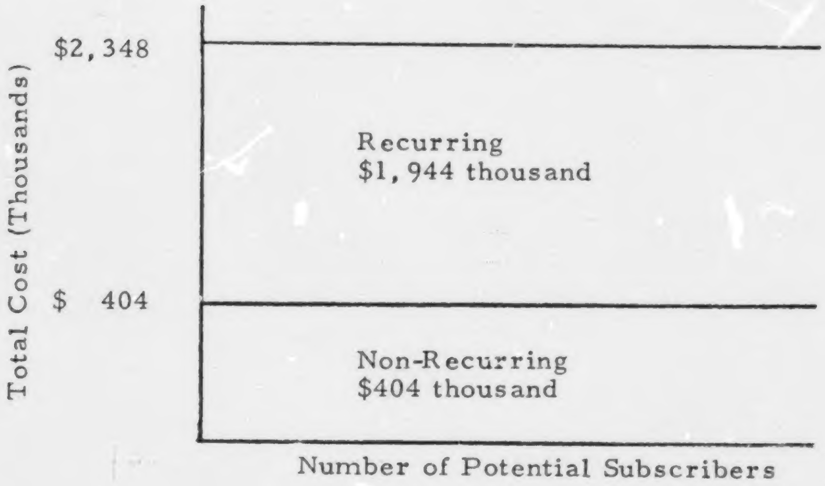
Figure 7-40 Total Cost and Revenue For 1/2 Hour Video Discs
(Example 3)



Note:

1. Table 7-19 used to prepare this chart.

Figure 7-41 30 Mile Radius OTA UHF ITV Station (Example 4)



Notes:

1. Number of potential subscribers is dependent on number of TV families in area of station coverage.
2. Costs are independent of number of viewers.
3. No revenue produced and no advertising included in the programming.
4. Recurring costs represent the accumulated present value of annual costs based on 10 years and 10% discount rate.

APPENDIX B

B.1 Introduction

MATHEMATICA has developed, specifically for this program, a cost relationship model for a generalized CATV and Pay TV system. The flow charts of the model, an example analysis, and data outputs are included in this appendix. It is especially designed to evaluate the net cash flow and the present values of various systems, both in terms of technical configuration (i.e., the cost model) and financial operation (i.e., the revenue model).

B.2 Cost Relationship Models

To use the cost elements it is necessary to decide on a system configuration of the size and capability required and then assemble the elements together to reflect this system. One of the methods of gathering the elements together is to establish a simplified system block diagram identifying the system components. The cost model is also a way of reflecting this system configuration to obtain a cost estimating relationship, and the cash flow, and capital required. This appendix provides three examples of the use of the model for obtaining cash flow.

The cost model is a computer program system designed and built to aid the analyst in the computation, accumulation, and display of the costs of delivery system of nearly any level of complexity. The cost model is not a model in the usual sense of the word. Rather, it is a flexible program system that helps the cost analyst to model a specific configuration, varying the components of systems through all levels. For example, the model is not restricted to only cable systems, microwave, and satellite systems, but can be anycombination of these carried out to whatever level desired. Further, that level may be a single system of one or a multiple combination of any of the above, including video disc and video tape usage and frame grabber channels.

The model can also be used to handle quantitative factors, e.g. number of Pay TV subscribers, number of miles of buried cables, or number of local origination studios, and can be varied for evaluation of a particular system configuration.

The cost model for a specific system basically is a flow model. For example, a general model for the CATV and Pay TV System Cost Modeling is shown in Figure B-1. This top level cost model is further defined by extending each major cost category into second level elements. These flow models are listed in the ITV System Analysis Sheet (Table B-1). The Analysis Sheet further provides the test references to the net cash flow analyses and the investment analysis. This particular model represents system 2 with a build-up to the size of 43,000 CATV and 26,000 Pay TV subscribers in five years (1974-1978) and is discussed further in the example analysis.

Another model represented by Table B-2 is a CATV network system of three headends interconnected with two microwave links. A system build-up to 43,000 CATV and 26,000 Pay TV subscribers has been applied by the program for this model. In the first year the master headend and local origination studio are completed. The transmission system installation is begun and homes associated with this headend are connected to the cable. As time progresses, all homes that are going to be connected in this area are put on the cable. The second headend and microwave link to the master headend are installed, and the homes in this area are connected to the cable as its installation proceeds. Finally, as the second area is completed, the third headend is added with a microwave link to the master headend, and the homes in the third area connected as the cable transmission system installation proceeds. Revenue from subscribers is accumulated as they are added to the system. The installation of Pay TV in the system starts in the first year but no revenue is received until the beginning of the second year. Once Pay TV is introduced its growth is assumed to occur quite rapidly and stabilize at the completion of the installations in the third area. System #3 is also discussed in this example analysis, with computer printouts provided and the investment return defined.

The cost models and revenue models can be combined to obtain an output to show the cash flow. This combination is shown in Figure B-2.

In Figure B-3 a model is shown for regional and national systems. One input to this model is the output of the CATV model. This model is used similarly to the CATV model. If we only want a single regional system costed, the factors associated with the national portion are entered as zeros (no data). Again, any cost relationship desired as an output is readily obtained by simply adding to the model the factor (s) desired and printout desired. To provide the national system, all pertinent cost factors are inserted into the model. The integration of revenue into the model allows cash flows and other output desired to be obtained.

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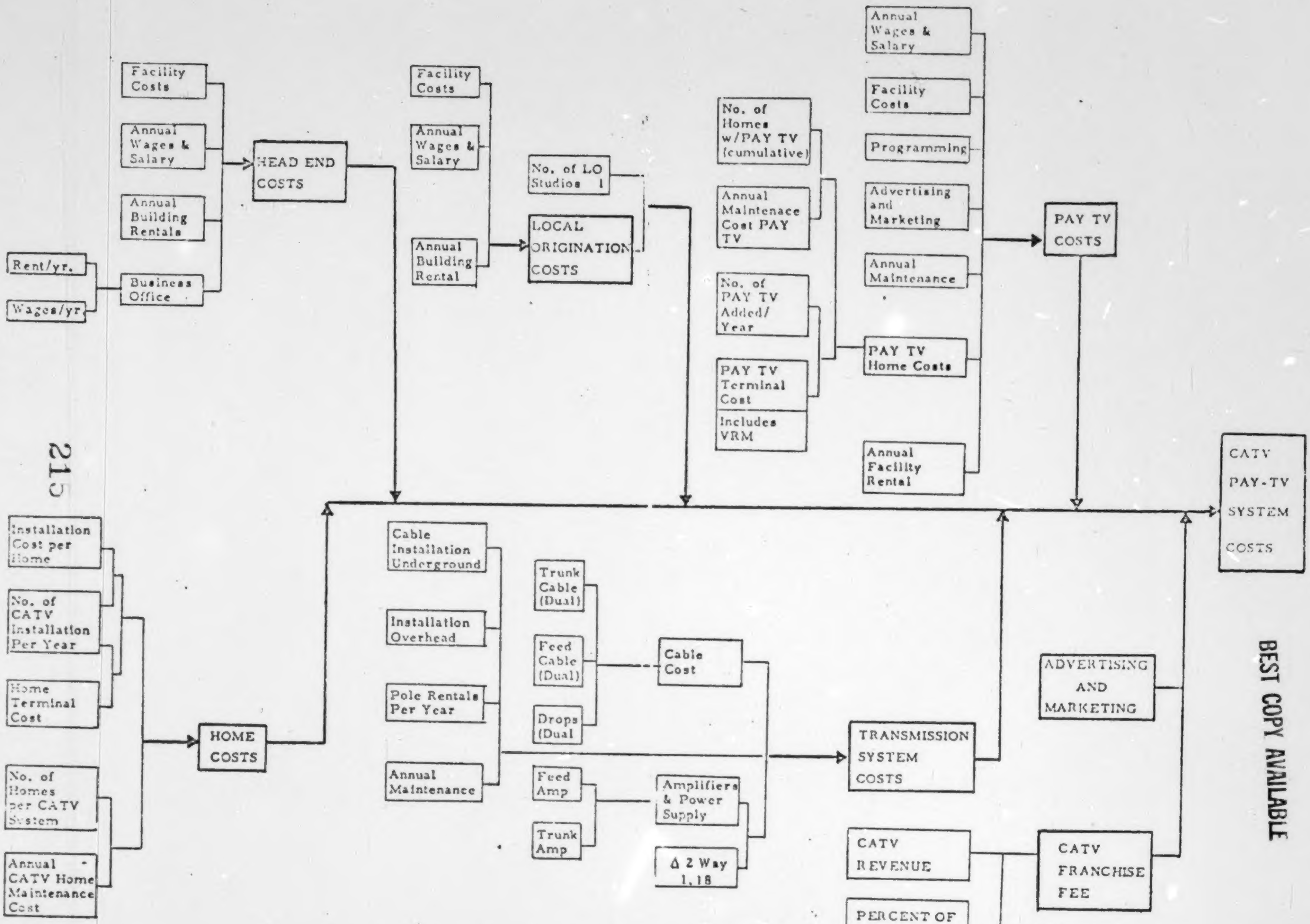

Rent/yr.
Wages/yr
Business Office
Facility Costs
Annual Wages & Salary
Annual Building Rentals
HEAD END COSTS
Facility Costs
Annual Wages & Salary
Annual Building Rental
No. of LO Studios 1
LOCAL ORIGINATION COSTS
No. of Homes w/PAY TV (cumulative)
Annual Maintenace Cost PAY TV
No. of PAY TV Added/ Year
PAY TV Terminal Cost
Includes VRM
Annual Wages & Salary
Facility Costs
Programming
Advertising and Marketing
Annual Maintenance
PAY TV Home Costs
Annual Facility Rental
PAY TV COSTS
CATV PAY-TV SYSTEM COSTS
Installation Cost per Home
No. of CATV Installation Per Year
Home Terminal Cost
No. of Homes per CATV System
Annual CATV Home Maintenance Cost
HOME COSTS
Cable Installation Underground
Installation Overhead
Pole Rentals Per Year
Annual Maintenance
Trunk Cable (Dual)
Feed Cable (Dual)
Drops (Dual
Cable Cost
Feed Amp
Trunk Amp
Amplifiers & Power Supply
Δ 2 Way 1.18
TRANSMISSION SYSTEM COSTS
ADVERTISING AND MARKETING
CATV REVENUE
PERCENT OF REVENUE 1.05
CATV FRANCHISE FEE

CATV/ PAY TV SYSTEM COST MODEL
Figure B-1

TABLE B-1

ITV SYSTEM ANALYSIS SHEET

Assumptions:		Delivery System Configuration	
CATV Subscribers	43,000	CATV and Pay TV System	System #2
Pay TV Subscribers	26,000		
Area of Coverage	50 sq. miles		
Dual Cable - 2 way			
Overhead Cabling			
Dense Urban Area			

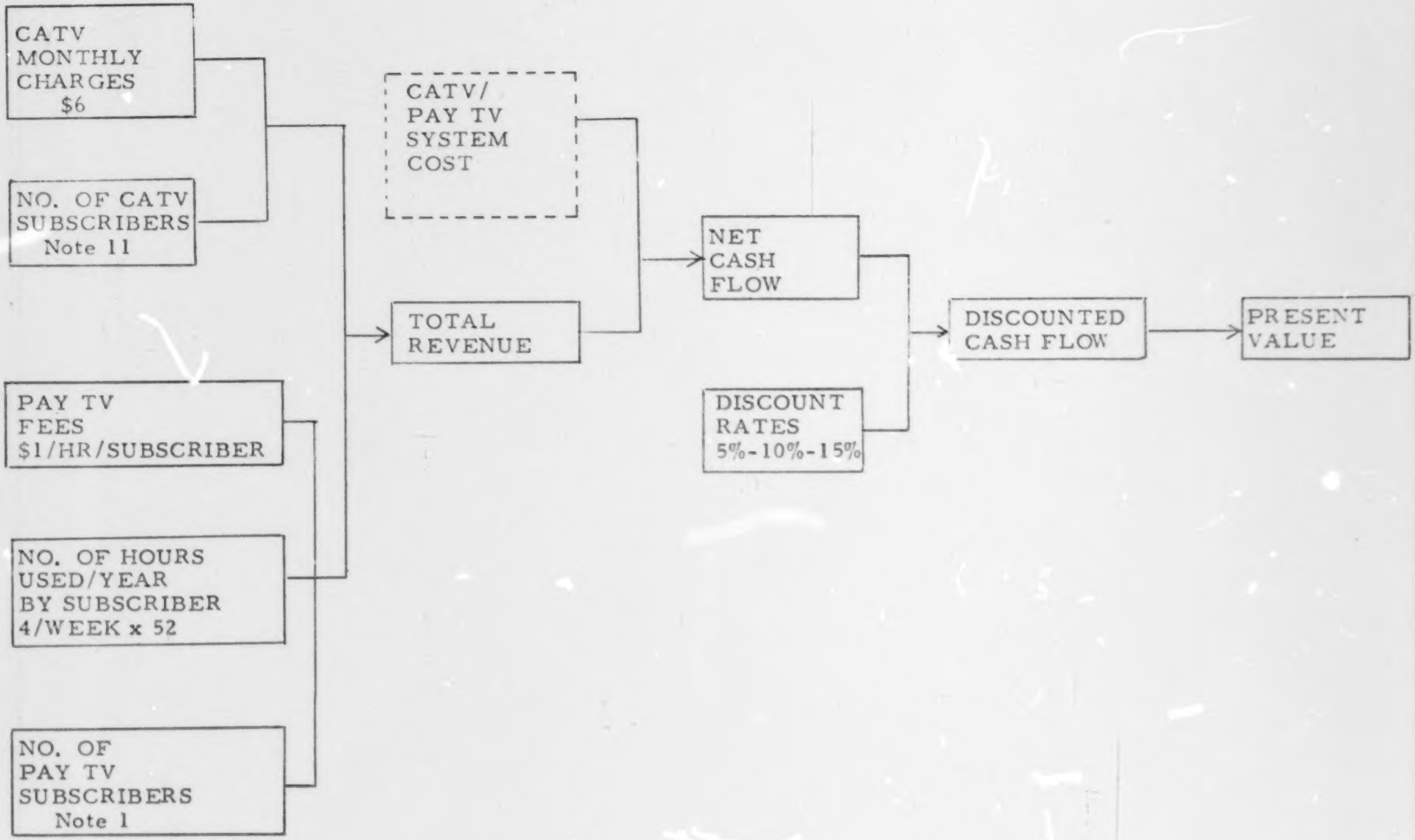
Top Level	Fig. No.	Title
Cost Model	B-1	CATV/Pay TV System Cost Model
Cash Flow Model	B-2	CATV/Pay TV Cash Flow Model
Second Level	Fig. No.	Title
Cost Models	B-6	Headend Costs
	B-7	Local Origination Costs
	B-8	Pay TV Costs
	B-9	Cable Transmission System Costs
	B-10	Home/Franchise Fee/Advertising and Marketing Costs
	Table No.	Title
Input Data	B-3	Cost Element Input Data
Net Cash Flow Analyses	Fig. No.	Title
o Discount Rate 5%	B-11	CATV/Cash Flow Analysis (5%)
o Discount Rate 10%	B-12	CATV Cash Flow Analysis (10%)
o Discount Rate 15%	B-13	CATV Cash Flow Analysis (15%)
Investment Analysis	Fig. No.	Title
	B-14	Return on Investment Analysis

TABLE B-2

ITV SYSTEM ANALYSIS SHEET

Assumptions:	Delivery System Configuration	
CATV Subscribers 43,000 Pay TV Subscribers 26,000 3 Areas Totalling 50 sq. miles Areas Interconnected by 2 Microwave Links Dual Cable - 2 way system Dense Urban Areas	CATV and Pay TV System (3 Headend Network)	System #3

Top Level	Fig. No.	Title
Cost Model	B-15	CATV/Pay TV System Cost Model (1 Master/2 Slave Headends)
Cash Flow Model	B-2	CATV/ Pay TV Cash Flow Model
Second Level	**Fig. No.**	**Title**
Cost Models	B-16	Headend Costs (CATV/Pay TV Network Model Cost)
	B-7	Local Origination Costs
	B-8	Pay TV Costs
	B-9	Cable Transmission System Costs
	B-10	Home/Franchise Fee/Advertising and Marketing Costs
	Table No.	**Title**
Input Data	B-2	Cost Element Input Data
Net Cash Flow Analyses	**Fig. No.**	**Title**
o Discount Rate 5%	B-17	CATV Cash Flow Analysis (5%)
o Discount Rate 10%	B-18	CATV Cash Flow Analysis (10%)
o Discount Rate 15%	B-19	CATV Cash Flow Analysis (15%)
Investment Analysis	**Fig. No.**	**Title**
	B-14	Return on Investment Analysis


CATV
MONTHLY
CHARGES
$6
NO. OF CATV
SUBSCRIBERS
Note 11
PAY TV
FEES
$1/HR/SUBSCRIBER
NO. OF HOURS
USED/YEAR
BY SUBSCRIBER
4/WEEK x 52
NO. OF
PAY TV
SUBSCRIBERS
Note 1
CATV/
PAY TV
SYSTEM
COST
TOTAL
REVENUE
NET
CASH
FLOW
DISCOUNT
RATES
5%-10%-15%
DISCOUNTED
CASH FLOW
PRESENT
VALUE

CATV - Pay TV

Cash Flow Model

(Notes: See Table B-3, pg. B-19)

Figure B-2

B. 3 Example Analyses

Three examples of cash flow analyses are presented to illustrate several configurations of CATV/Pay TV systems. For each system the following steps have been used to develop the cash flow model and to obtain the analyses outputs:

1. A CATV/Pay TV system is structured to a particular configuration. A strand map is used as an implementation tool.

2. A cost hierarchy (flow model) is developed to permit more flexible manipulation of quantities and elements and show the cost relationship.

3. The cost models are computerized to handle a large number of inputs, to accumulate cost elements at various levels, to provide annual costs, and allow variations of any of the many elements to determine their impact and model sensitivity.

4. The cost elements associated with each subsystem represent a product or services. For example, a coaxial cable system and its installation costs and operational costs are collected under Transmission System Costs.

5. The revenues from CATV and Pay TV operations are represented by fees placed upon the users. The rates are $6 per month for CATV and $2.50 per program (2 hours) viewing for Pay TV.

6. The CATV franchise fee, payable to the local government, is equal to the 5% of the gross receipts.

7. Discount rates of 5%, 10%, and 15% are applied to the Net Cash Flow to give the Discounted Net Cash Flow.

8. Inflation rate of 5% annual increase is applied to all wages.

9. The Present Value, the algebraic sum of Discounted Net Cash Flow, is calculated.

10. The rate of return on investment is obtained from a graph plotting Present Values and Discount Rates. The % point at which the present value goes to zero is the rate of return for that investment.

The three types of system configurations and their assumptions are as follows.

System #1

The size of this system is very large and represents a dense urban area. It is a system made up of 83,000 subscribers in a 100 square mile area. It is assumed that a CATV system will service this area with one headend and one local origination studio. It is further assumed for simplicity that the system is installed and completed at the start of the time shown and that revenue begins immediately (the subsequent models 2 and 3 provide for realistic probable system build-up over a number of years, and revenue only for that portion of the system completed with installed headend, transmission system and home-installed equipment). A further assumption in this system is that the transmission system is an overhead system, not underground, and this same assumption is also made for the other examples that follow. This first example also does not include advertising and marketing costs and only assumes a minimal Pay TV program cost. Again subsequent models for systems #2 and #3 have approximately a million dollars per year for Pay TV programming cost in comparison.

The assumptions are:

1.	Number of CATV subscribers (penetration p = 0.5)	83,000
2.	Number of Pay TV subscribers (p' = 0.6 of CATV subscribers)	49,000
3.	Area of Coverage	100 sq. miles
4.	Dual Cable - 2-way system	
5.	Dense Urban Area.	

Figure B-4 shows the results of this system. It should be pointed out that this example analysis is for illustrative purposes only. The example uses the model in Figure B-5.

System #2

A system of 43,000 subscribers, one headend, and with system build-up as well as revenue build-up as subscribers are added to the system. The cost models and the input date for this system are listed in Table B-1.

The assumptions are:

1.	Number of CATV subscribers ((penetration $p = 0.5$)	43,000
2.	Number of Pay TV subscribers ($p' = 0.6$)	26,000
3.	Area of Coverage	50 sq. miles
4.	Dual Cable - 2-way system	
5.	Dense Urban Area.	

See Table B-1 for net cash flow analyses for System #2. The discount rates of 5%, 10%, and 15% are applied to the Net Cash Flow. The investment return for this system is approximately 20%, as shown in Figure B-14.

System #3

A system of 43,000 subscribers and three headends interconnected with two microwave links to represent a network model of three urban areas separated by 10-15 miles. The cost models and the input data figure numbers are shown in Table B-2

The assumptions are:

1.	Number of CATV subscribers	43,000
2.	Number of Pay TV subscribers ($p' = 0.6$)	26,000

3. 3 areas totalling 50 sq. miles
4. Areas interconnected by 2 microwave links
5. Dual Cable - 2 way system
6. Dense Urban Areas

The cash flow analyses for this CATV network are listed in Table B-2. Figure B-14 shows that a 17% return can be expected from this configuration.

```
                                                                                          OCTOBER 20, 1973

                                              CATV & PAY TV CASH FLOW ANALYSIS
                                              ( IN THOUSANDS OF DOLLARS )
                                              ( DISCOUNT RATE 10 PERCENT )
CATV SUBSCRIBERS   83000
PAY TV SUBSCRIBERS 49000
AREA OF COVERAGE 100 SQ MI
DUAL CABLE - 2 WAY SYSTEM
DENSE URBAN AREA

                                        1974       1975       1976       1977       1978       1979       1980
  TRANSMISSION SYSTEM COSTS           6490.15     112.82     112.82     112.82     112.82     112.82     112.82
  HOME COSTS                          7221.00     996.00     996.00     996.00     996.00     996.00     996.00
  HEAD END COST                        170.75     139.50     145.54     151.88     158.53     165.52     172.86
  LOCAL ORIGINATION STUDIO              87.00      56.50      58.07      59.73      61.47      63.29      65.20
  PAY TV COSTS (INCL. HOME UNITS)     8495.60     823.45     825.40     827.44     829.58     831.83     834.19
                                      -------    -------    -------    -------    -------    -------    -------
TOTAL SYSTEM COSTS                   22464.50    2128.28    2137.83    2147.87    2158.40    2169.46    2181.08

  CATV REVENUE                        5976.00    5976.00    5976.00    5976.00    5976.00    5976.00    5976.00
  PAY TV REVENUE                     10192.00   10192.00   10192.00   10192.00   10192.00   10192.00   10192.00
                                     --------   --------   --------   --------   --------   --------   --------
TOTAL REVENUE                        16168.00   16168.00   16168.00   16168.00   16168.00   16168.00   16168.00

NET CASH FLOW                        -6296.50   14039.72   14030.16   14020.13   14009.60   13998.54   13986.92
DISCOUNTED CASH FLOW                 -6296.50   12762.10   11592.86   10530.37    9564.91    8687.64    7890.51
PRESENT VALUE                        54731.89
```

Figure B-4 CATV Cash Flow Analysis

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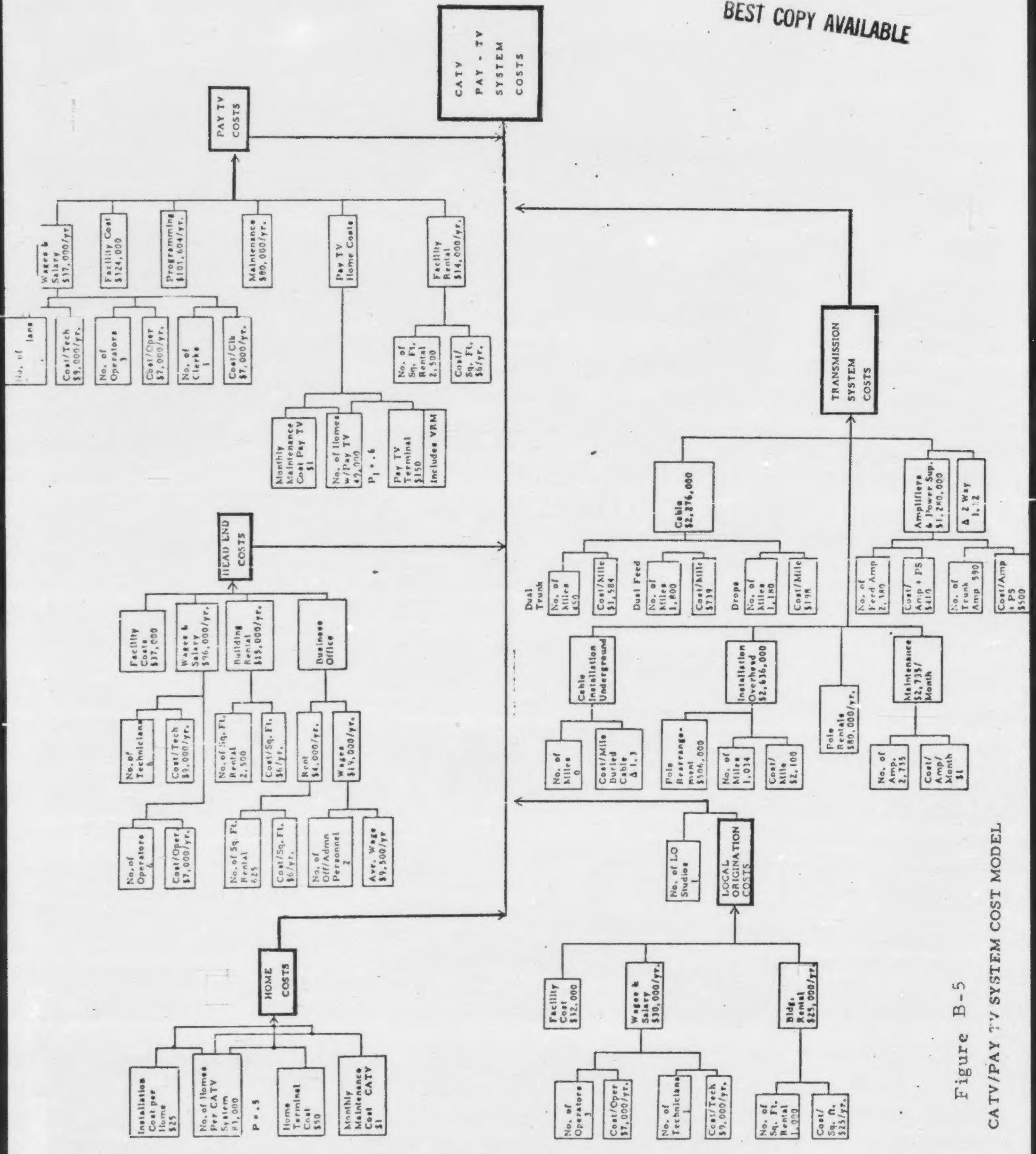
CATV PAY - TV SYSTEM COSTS
PAY TV COSTS
Wages & Salary $37,000/yr
Facility Cost $124,000
Programming $101,604/yr.
Maintenance $80,000/yr.
Pay TV Home Costs
Facility Rental $14,000/yr.
No. of ...ians
Cost/Tech $9,000/yr.
No. of Operators 3
Cost/Oper $7,000/yr.
No. of Clerks 1
Cost/Clk $7,000/yr.
No. of Sq. Ft. Rental 2,500
Cost/ Sq. Ft. $6/yr.
Monthly Maintenance Cost Pay TV $1
No. of Homes w/Pay TV 49,000
P1 = .6
Pay TV Terminal $150
Includes VRM
HEAD END COSTS
Facility Costs $37,000
Wages & Salary $96,000/yr.
Building Rental $15,000/yr.
Business Office
No.of Technicians 6
Cost/Tech $9,000/yr.
No. of Sq. Ft. Rental 2,500
Cost/Sq. Ft. $6/yr.
Rent $4,000/yr.
Wages $19,000/yr.
No.of Operators 6
Cost/Oper. $7,000/yr.
No. of Sq. Ft. Rental 625
Cost/Sq. Ft. $6/yr.
No. of Off/Admn Personnel 2
Avr. Wage $9,500/yr
HOME COSTS
Installation Cost per Home $25
No. of Homes Per CATV System 81,000
P = .5
Home Terminal Cost $50
Monthly Maintenance Cost CATV $1
TRANSMISSION SYSTEM COSTS
Cable $2,276,000
Amplifiers & Power Sup. $1,280,000
Δ 2 Way 1.12
Dual Trunk
No. of Miles 450
Cost/Mile $1,584
Dual Feed
No. of Miles 1,800
Cost/Mile $739
Drops
No. of Miles 1,180
Cost/Mile $198
No. of Feed Amp 2,180
Cost/ Amp + PS $410
No. of Trunk Amp 590
Cost/Amp + PS $500
Cable Installation Underground
Installation Overhead $2,636,000
Pole Rentals $80,000/yr.
Maintenance $2,735/ Month
No. of Miles 0
Cost/Mile Buried Cable Δ 1.3
Pole Rearrangement $506,000
No. of Miles 1,034
Cost/ Mile $2,100
No. of Amp. 2,735
Cost/ Amp/ Month $1
No. of LO Studios 1
LOCAL ORIGINATION COSTS
Facility Cost $12,000
Wages & Salary $30,000/yr.
Bldg. Rental $25,000/yr.
No. of Operators 3
Cost/Oper $7,000/yr.
No. of Technicians 1
Cost/Tech $9,000/yr.
No. of Sq. Ft. Rental 1,000
Cost/ Sq. ft. $25/yr.

Figure B-5

CATV/PAY TV SYSTEM COST MODEL

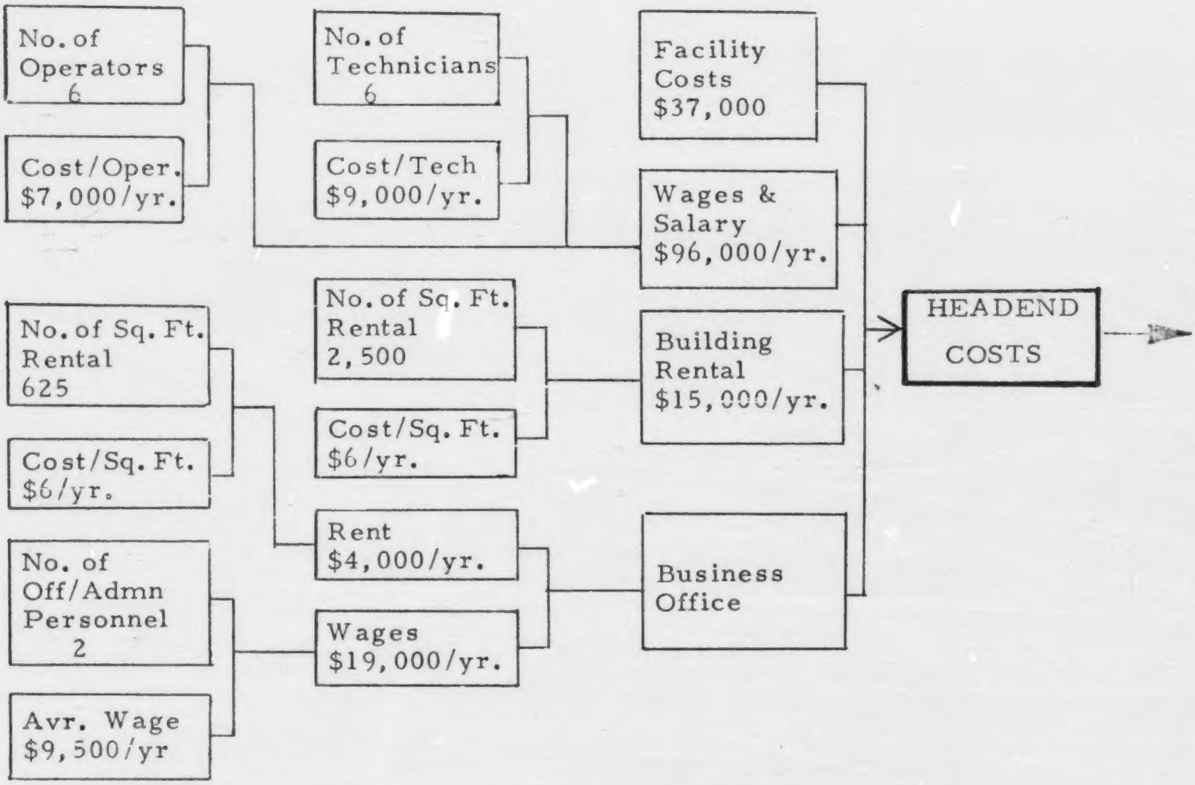
No. of Operators 6
Cost/Oper. $7,000/yr.
No. of Technicians 6
Cost/Tech $9,000/yr.
Facility Costs $37,000
Wages & Salary $96,000/yr.
No. of Sq. Ft. Rental 625
Cost/Sq. Ft. $6/yr.
No. of Sq. Ft. Rental 2,500
Cost/Sq. Ft. $6/yr.
Building Rental $15,000/yr.
HEADEND COSTS
No. of Off/Admn Personnel 2
Avr. Wage $9,500/yr
Rent $4,000/yr.
Wages $19,000/yr.
Business Office

Figure B-6

Headend Costs

CATV/ Pay TV Cost Model

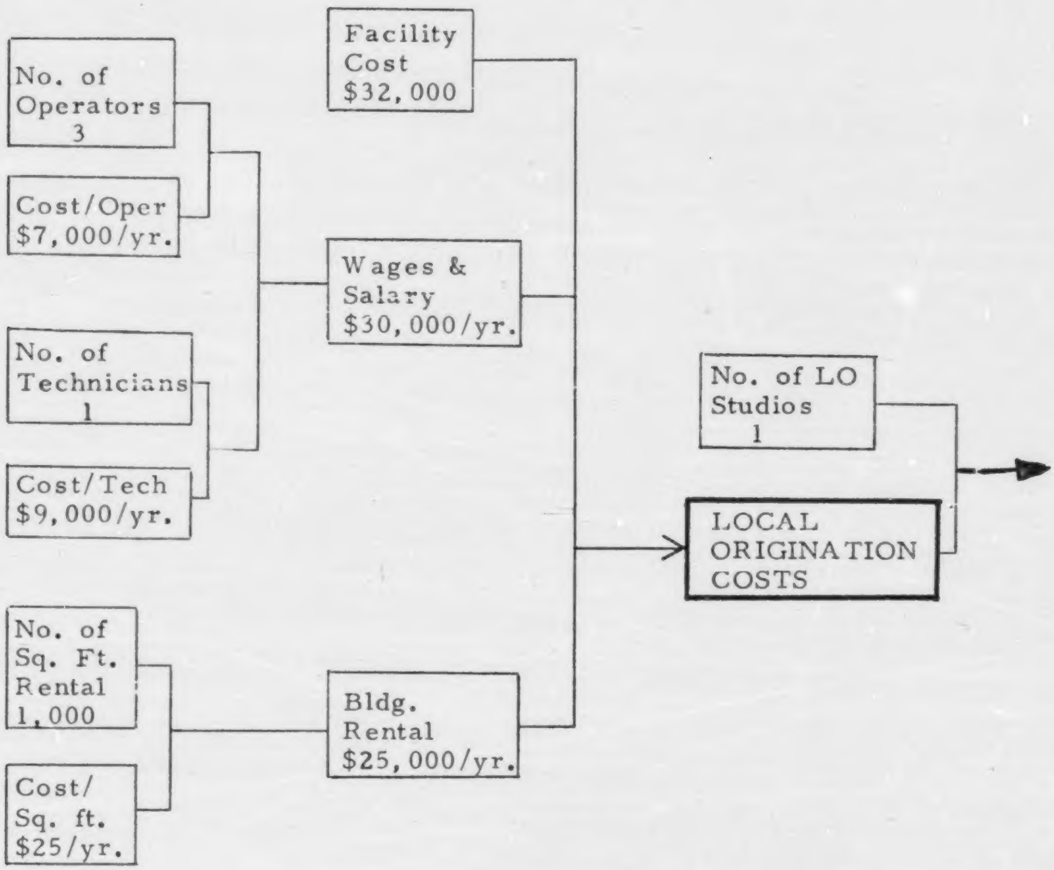
Facility Cost $32,000
No. of Operators 3
Cost/Oper $7,000/yr.
Wages & Salary $30,000/yr.
No. of Technicians 1
Cost/Tech $9,000/yr.
No. of LO Studios 1
LOCAL ORIGINATION COSTS
No. of Sq. Ft. Rental 1,000
Cost/ Sq. ft. $25/yr.
Bldg. Rental $25,000/yr.

Figure B-7

Local Origination Costs

(CATV/Pay TV Cost Model)

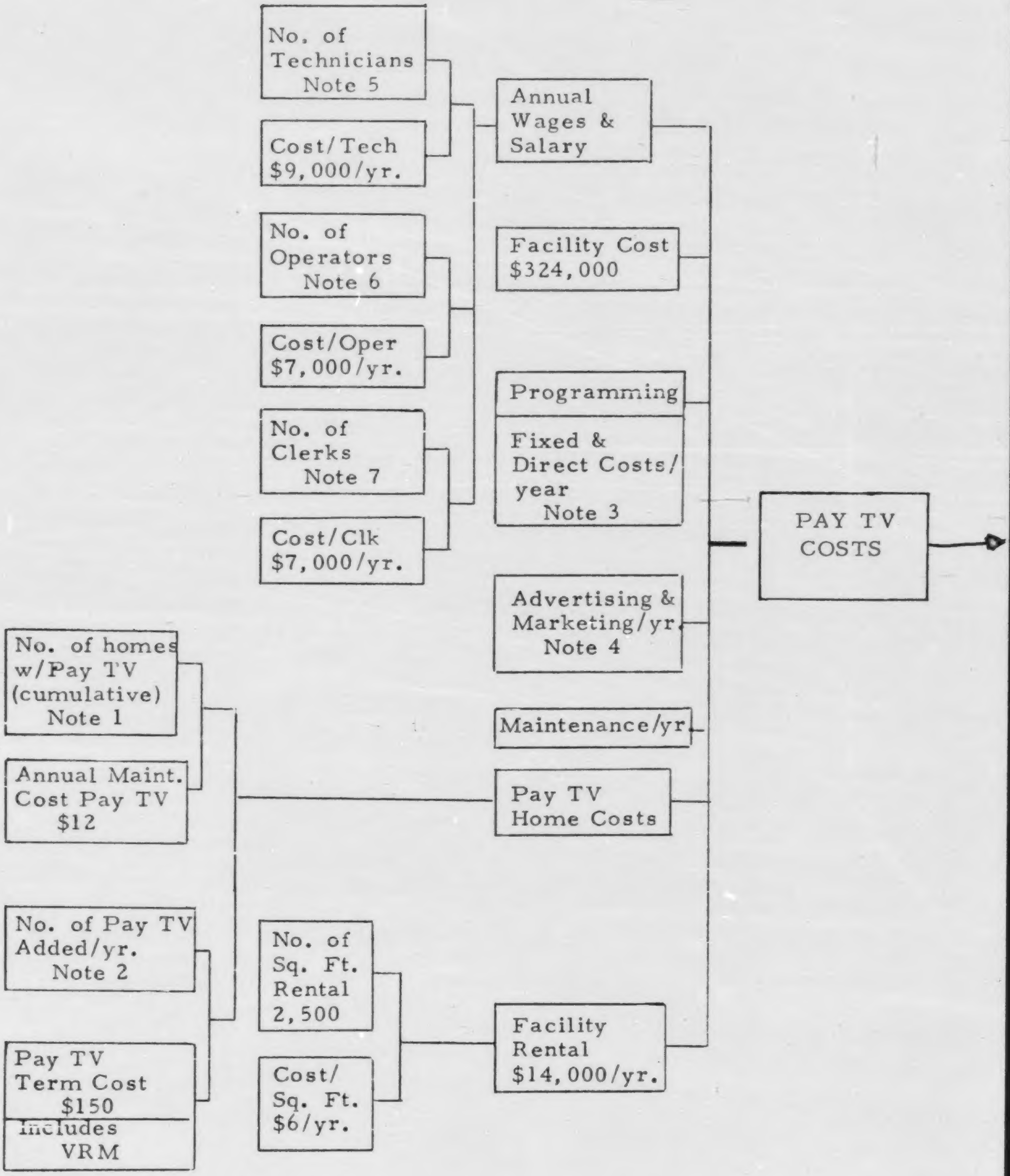
No. of Technicians Note 5
Cost/Tech $9,000/yr.
No. of Operators Note 6
Cost/Oper $7,000/yr.
No. of Clerks Note 7
Cost/Clk $7,000/yr.
Annual Wages & Salary
Facility Cost $324,000
Programming
Fixed & Direct Costs/year Note 3
Advertising & Marketing/yr. Note 4
Maintenance/yr.
Pay TV Home Costs
Facility Rental $14,000/yr.
PAY TV COSTS
No. of homes w/Pay TV (cumulative) Note 1
Annual Maint. Cost Pay TV $12
No. of Pay TV Added/yr. Note 2
Pay TV Term Cost $150
Includes VRM
No. of Sq. Ft. Rental 2,500
Cost/Sq. Ft. $6/yr.

Figure B-8

Pay TV Costs

(CATV/Pay TV Cost Model)
(Notes: See Table B-3, Pg. B-19)

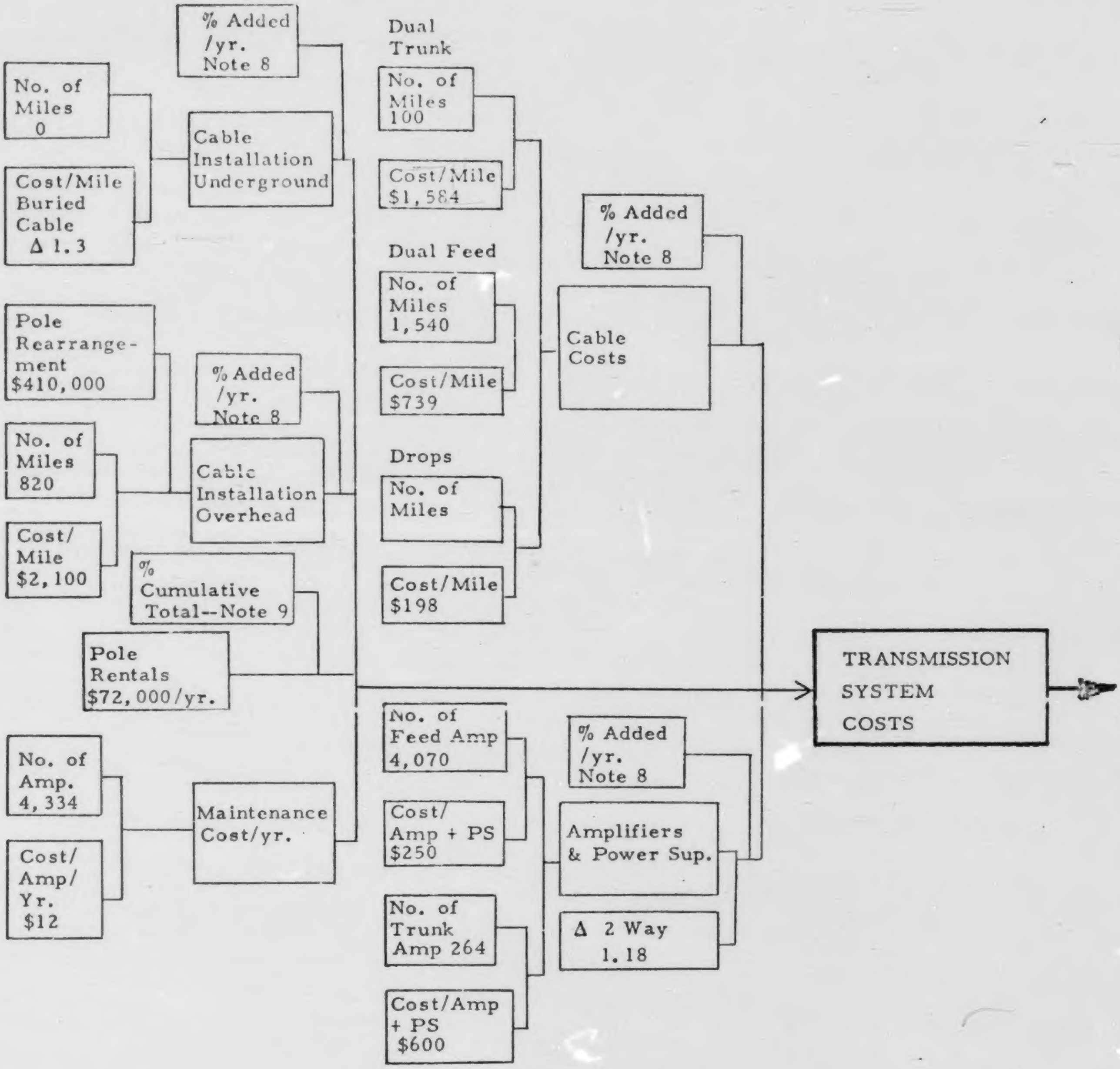
% Added /yr. Note 8
No. of Miles 0
Cost/Mile Buried Cable Δ 1.3
Cable Installation Underground
Dual Trunk
No. of Miles 100
Cost/Mile $1,584
Dual Feed
No. of Miles 1,540
Cost/Mile $739
Drops
No. of Miles
Cost/Mile $198
% Added /yr. Note 8
Cable Costs
Pole Rearrange-ment $410,000
% Added /yr. Note 8
No. of Miles 820
Cable Installation Overhead
Cost/Mile $2,100
% Cumulative Total--Note 9
Pole Rentals $72,000/yr.
TRANSMISSION SYSTEM COSTS
No. of Amp. 4,334
Cost/Amp/Yr. $12
Maintenance Cost/yr.
No. of Feed Amp 4,070
Cost/Amp + PS $250
% Added /yr. Note 8
Amplifiers & Power Sup.
No. of Trunk Amp 264
Cost/Amp + PS $600
Δ 2 Way 1.18

Figure B-9

Cable Transmission System Costs

(CATV/ Pay TV System Cost Model)

(Notes: See Table B-3, Pg. B-19)

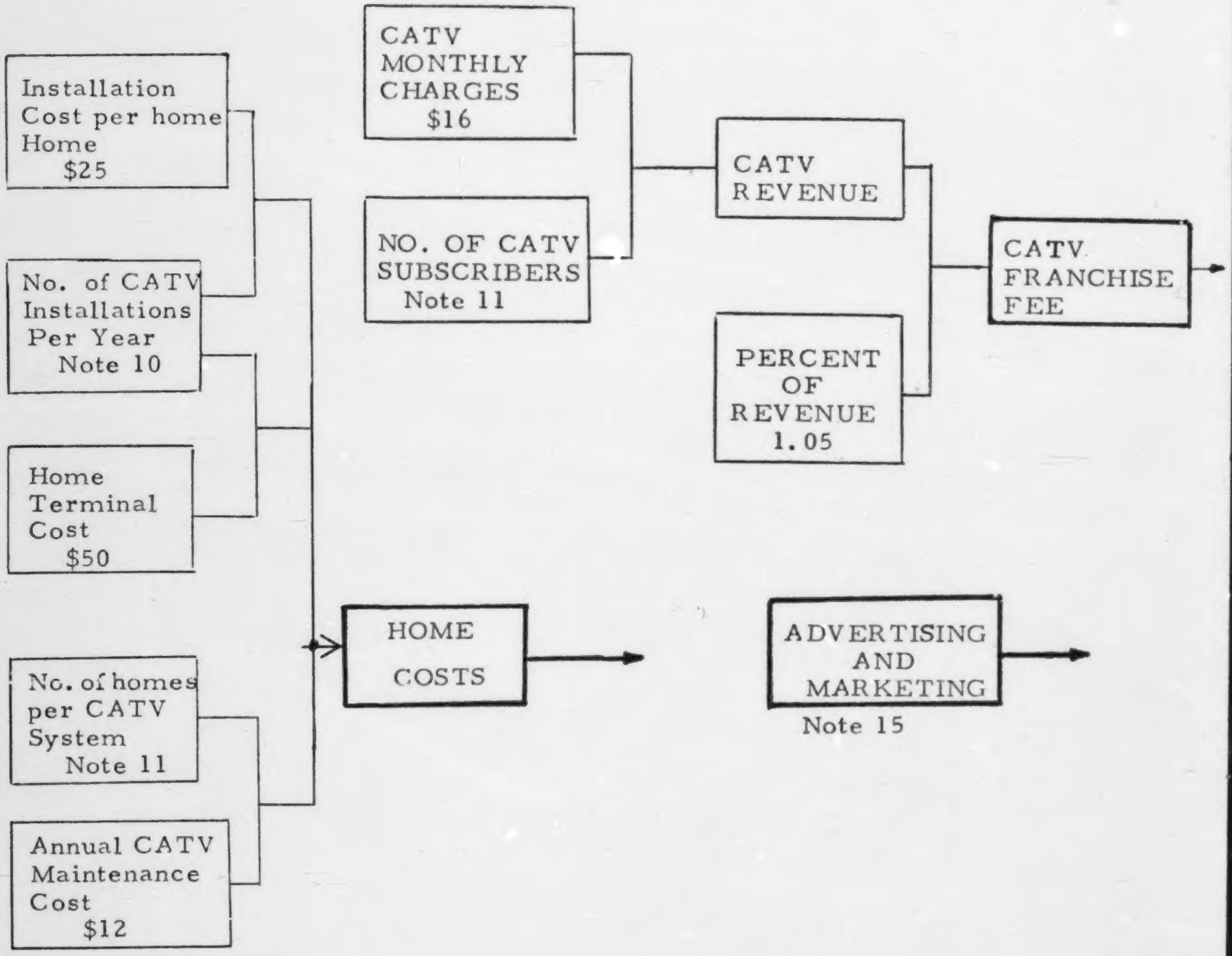
Installation Cost per home Home $25
No. of CATV Installations Per Year Note 10
Home Terminal Cost $50
No. of homes per CATV System Note 11
Annual CATV Maintenance Cost $12
HOME COSTS
CATV MONTHLY CHARGES $16
NO. OF CATV SUBSCRIBERS Note 11
CATV REVENUE
PERCENT OF REVENUE 1.05
CATV FRANCHISE FEE
ADVERTISING AND MARKETING
Note 15

Figure B-10

Home/Franchise Fee/Advertising & Marketing Costs

CATV/Pay TV Cost Model)

(Notes: See Table B-3, Pg. B-19)

Table B-3

Cost Element Input Data

NOTES	COST ELEMENTS	1974	1975	1976	1977	1978	1979	1980
1	No. of Homes w/Pay TV (cumulative)	0	1,200	7,200	15,600	26,000	26,000	26,000
2	No. of Homes w/Pay TV added per year	0	1,200	6,000	8,400	10,400	0	0
3.	Programming	0	$750,000	$750,000	$750,000	$750,000	$750,000	$750,000
4	Advertising & Marketing	0	$500,000	$200,000	$200,000	$200,000	$200,000	$200,000
5	No. of Technician(s)	0	1	1	1	1	1	1
6	No. of Operators	0	3	3	3	3	3	3
7	No. of Clerks	0	1	1	1	1	1	1

Table B-3 (continued)

NOTES	COST ELEMENTS	1974	1975	1976	1977	1978	1979	1980
8	% CATV homes added per year	.046	.093	.140	.280	.441	0	0
9	% CATV homes cumulative total per year	.046	.139	.279	.559	1.0	1.0	1.0
10	Homes added per year (CATV)	2,000	4,000	6,000	12,000	19,000	0	0
11	No. of Homes per CATV System	2,000	6,000	12,000	24,000	43,000	43,000	43,000
12	Facility Costs	$37,000	0	$ 37,000	$ 37,000	0	0	0
13	Microwave Costs	0	0	$113,000	$113,000	0	0	0
14	No. of Headends (cumulative)	1	1	2	3	3	3	3
15	Advertising and Marketing	$100,000	$90,000	$ 90,000	$ 90,000	$90,000	$90,000	$90,000

OCTOBER 24, 1973

CATV & PAY TV CASH FLOW ANALYSIS
(IN THOUSANDS OF DOLLARS)
(DISCOUNT RATE 5 PERCENT)

CATV SUBSCRIBERS 43000
PAY TV SUBSCRIBERS 26000
AREA OF COVERAGE 50 SQ MI
DUAL CABLE - 2 WAY SYSTEM
DENSE URBAN AREA

	1974	1975	1976	1977	1978	1979	1980
TRANSMISSION SYSTEM COSTS	299.08	554.84	813.98	1576.01	2460.93	124.01	124.01
HOME COSTS	174.00	372.00	594.00	1188.00	1941.00	516.00	516.00
HEAD END COST	170.75	139.50	145.54	151.88	158.53	165.52	172.86
LOCAL ORIGINATION STUDIO	87.00	56.50	58.07	59.73	61.47	63.29	65.20
ADVERTISING AND MARKETING	100.00	90.00	90.00	90.00	90.00	90.00	90.00
PAY TV COSTS (INCL. HOME UNITS)	339.00	1478.25	2072.19	2535.03	2961.97	1404.22	1406.58
TOTAL SYSTEM COSTS	1169.84	2691.09	3773.79	5600.66	7673.90	2363.05	2374.66
CATV REVENUE	144.00	432.00	864.00	1728.00	3096.00	3096.00	3096.00
PAY TV REVENUE	0.00	249.60	1497.60	3244.80	5408.00	5408.00	5408.00
TOTAL REVENUE	144.00	681.60	2361.60	4972.80	8504.00	8504.00	8504.00
NET CASH FLOW	-1025.83	-2009.49	-1412.18	-627.86	830.10	6140.95	6129.34
DISCOUNTED CASH FLOW	-1025.83	-1913.64	-1280.67	-542.23	682.69	4809.55	4571.47
PRESENT VALUE	5301.34						

Figure B-11 CATV Cash Flow Analysis

OCTOBER 24, 1973

CATV & PAY TV CASH FLOW ANALYSIS

(IN THOUSANDS OF DOLLARS)

(DISCOUNT RATE 10 PERCENT)

CATV SUBSCRIBERS 43000

PAY TV SUBSCRIBERS 26000

AREA OF COVERAGE 50 SQ MI

DUAL CABLE - 2 WAY SYSTEM

DENSE URBAN AREA

	1974	1975	1976	1977	1978	1979	1980
TRANSMISSION SYSTEM COSTS	299.08	554.84	813.98	1576.01	2460.93	124.01	124.01
HOME COSTS	174.00	372.00	594.00	1188.00	1941.00	516.00	516.00
HEAD END COST	170.75	139.50	145.54	151.88	158.53	165.52	172.86
LOCAL ORIGINATION STUDIO	87.00	56.50	58.07	59.73	61.47	63.29	65.20
ADVERTISING AND MARKETING	100.00	90.00	90.00	90.00	90.00	90.00	90.00
PAY TV COSTS (INCL. HOME UNITS)	339.00	1478.25	2072.19	2535.03	2961.97	1404.22	1406.58
TOTAL SYSTEM COSTS	1169.84	2691.09	3773.79	5600.66	7673.90	2363.05	2374.65
CATV REVENUE	144.00	432.00	864.00	1728.00	3096.00	3096.00	3096.00
PAY TV REVENUE	0.00	249.60	1497.60	3244.80	5408.00	5408.00	5408.00
TOTAL REVENUE	144.00	681.60	2361.60	4972.80	8504.00	8504.00	8504.00
NET CASH FLOW	-1025.83	-2009.49	-1412.18	-627.86	830.10	6140.95	6129.34
DISCOUNTED CASH FLOW	-1025.83	-1826.63	-1166.86	-471.58	566.74	3811.14	3457.78
PRESENT VALUE	3344.77						

Figure B-12 CATV Cash Flow Analysis

OCTOBER 24, 1973

CATV & PAY TV CASH FLOW ANALYSIS
(IN THOUSANDS OF DOLLARS)
(DISCOUNT RATE 15 PERCENT)

CATV SUBSCRIBERS 43000
PAY TV SUBSCRIBERS 26000
AREA OF COVERAGE 50 SQ MI
DUAL CABLE - 2 WAY SYSTEM
DENSE URBAN AREA

	1974	1975	1976	1977	1978	1979	1980
TRANSMISSION SYSTEM COSTS	299.08	554.84	813.98	1576.01	2460.93	124.01	124.01
HOME COSTS	174.00	372.00	594.00	1188.00	1941.00	516.00	516.00
HEAD END COST	170.75	139.50	145.54	151.88	158.53	165.52	172.86
LOCAL ORIGINATION STUDIO	87.00	56.50	58.07	59.73	61.47	63.29	65.20
ADVERTISING AND MARKETING	100.00	90.00	90.00	90.00	90.00	90.00	90.00
PAY TV COSTS (INCL. HOME UNITS)	339.00	1478.25	2072.19	2535.03	2961.97	1404.22	1406.58
TOTAL SYSTEM COSTS	1169.84	2691.00	3773.79	5600.66	7673.90	2363.05	2374.66
CATV REVENUE	144.00	432.00	864.00	1728.00	3096.00	3096.00	3096.00
PAY TV REVENUE	0.00	249.60	1497.60	3244.80	5408.00	5408.00	5408.00
TOTAL REVENUE	144.00	681.60	2361.60	4972.80	8504.00	8504.00	8504.00
NET CASH FLOW	-1025.83	-2009.49	-1412.18	-627.86	830.10	6140.95	6129.34
DISCOUNTED CASH FLOW	-1025.83	-1747.25	-1067.65	-412.73	474.47	3051.99	2648.69
PRESENT VALUE	1921.69						

Figure B-13 CATV Cash Flow Analysis

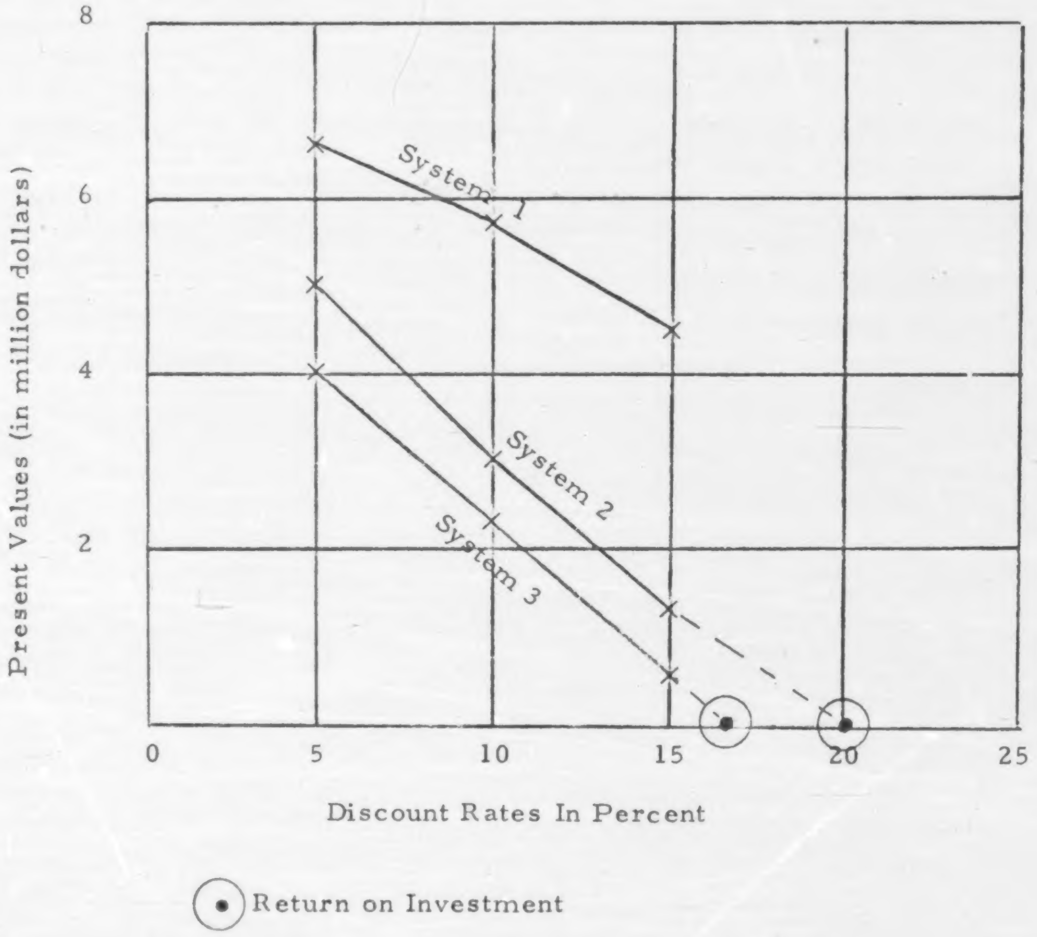

Figure B-14 Return on Investment Analysis

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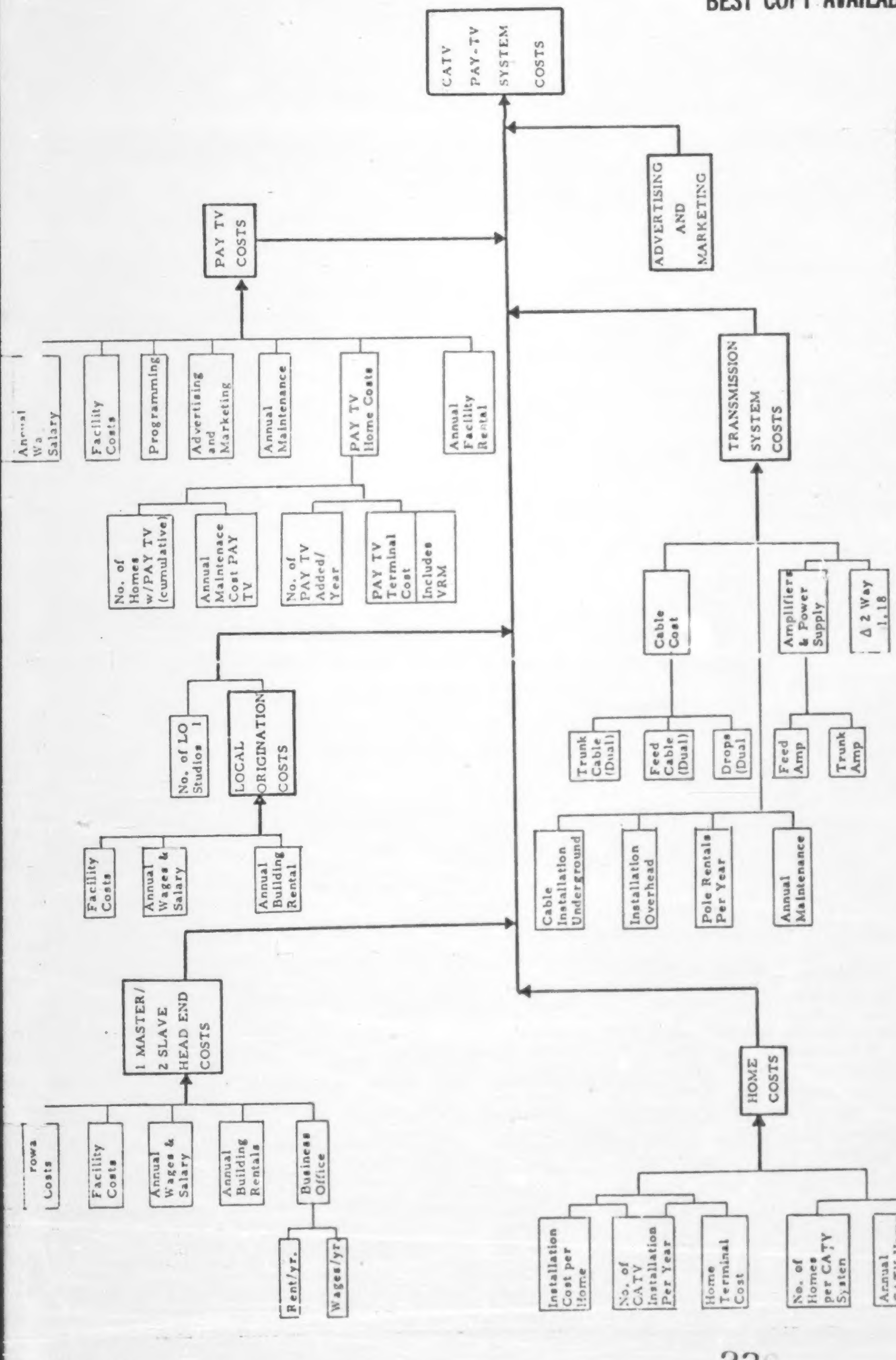
CATV PAY-TV SYSTEM COSTS
PAY TV COSTS
ADVERTISING AND MARKETING
Annual Wa Salary
Facility Costs
Programming
Advertising and Marketing
Annual Maintenance
PAY TV Home Costs
Annual Facility Rental
No. of Homes w/PAY TV (cumulative)
Annual Maintenace Cost PAY TV
No. of PAY TV Added/ Year
PAY TV Terminal Cost
Includes VRM
TRANSMISSION SYSTEM COSTS
Cable Cost
Amplifiers & Power Supply
Δ 2 Way 1.18
Trunk Cable (Dual)
Feed Cable (Dual)
Drops (Dual
Feed Amp
Trunk Amp
Cable Installation Underground
Installation Overhead
Pole Rentals Per Year
Annual Maintenance
No. of LO Studios 1
LOCAL ORIGINATION COSTS
Facility Costs
Annual Wages & Salary
Annual Building Rental
1 MASTER/ 2 SLAVE HEAD END COSTS
rowa Costs
Facility Costs
Annual Wages & Salary
Annual Building Rentals
Business Office
Rent/yr.
Wages/yr
HOME COSTS
Installation Cost per Home
No. of CATV Installation Per Year
Home Terminal Cost
No. of Homes per CATV System
Annual CATV Home Maintenance Cost

CATV/PAY TV SYSTEM COST MODEL
(1 MASTER/2 SLAVE HEAD ENDS)

Figure B-15

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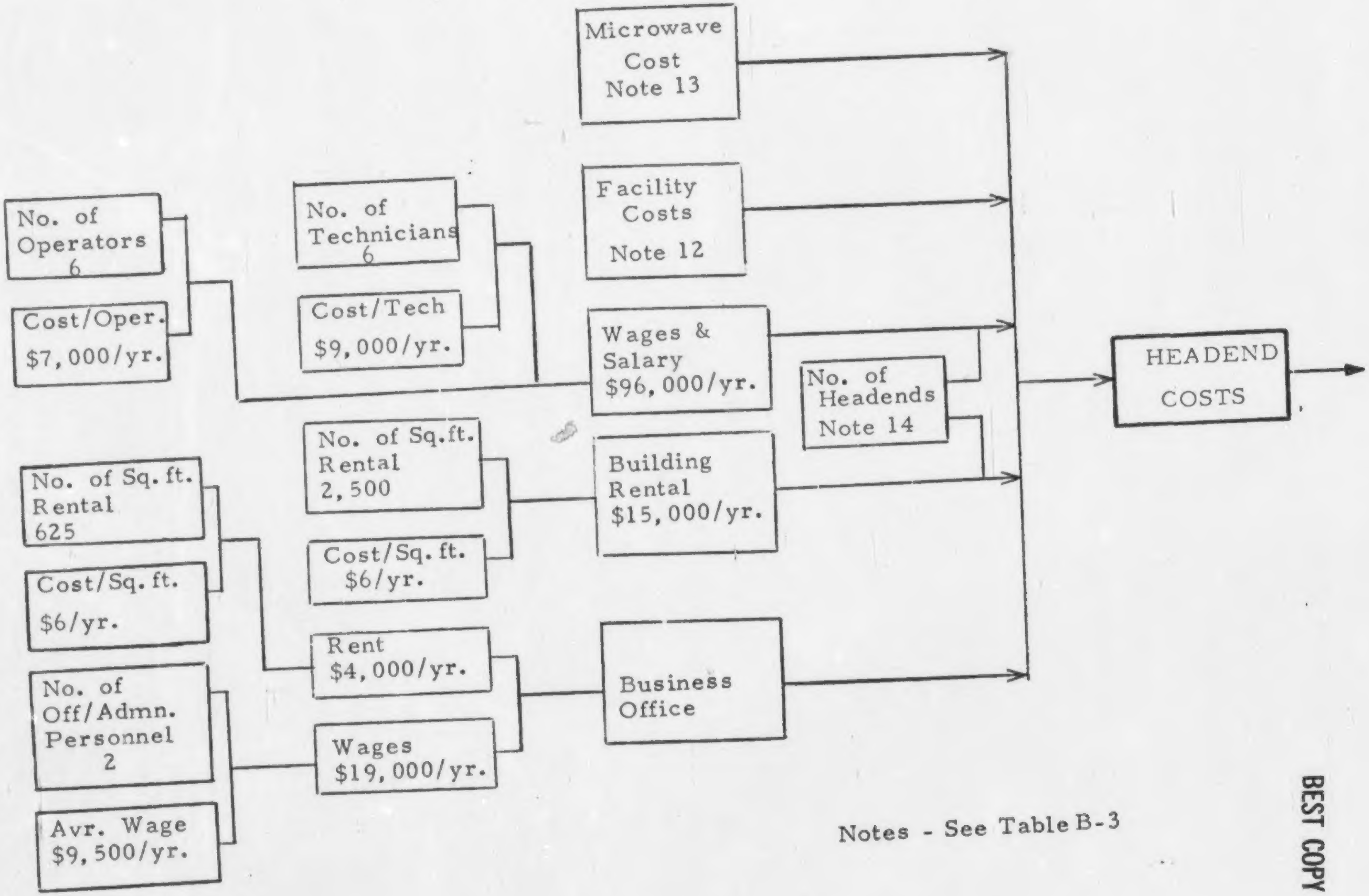
Microwave Cost Note 13
Facility Costs Note 12
Wages & Salary $96,000/yr.
No. of Headends Note 14
Building Rental $15,000/yr.
Business Office
HEADEND COSTS
No. of Operators 6
Cost/Oper. $7,000/yr.
No. of Technicians 6
Cost/Tech $9,000/yr.
No. of Sq.ft. Rental 2,500
Cost/Sq.ft. $6/yr.
No. of Sq. ft. Rental 625
Cost/Sq. ft. $6/yr.
Rent $4,000/yr.
No. of Off/Admn. Personnel 2
Avr. Wage $9,500/yr.
Wages $19,000/yr.

Notes - See Table B-3

FigureB-16
Headend Costs
CATV/Pay TV Network Model Cost

OCTOBER 25, 1973

CATV & PAY TV CASH FLOW ANALYSIS
(IN THOUSANDS OF DOLLARS)
(DISCOUNT RATE 5 PERCENT)

CATV SUBSCRIBERS 43000
PAY TV SUBSCRIBERS 26000
3 AREAS TOTALLING 50 SQ MI
AREAS INTERCONNECTED BY 2 MICROWAVE LINKS
DUAL CABLE - 2 WAY SYSTEM
DENSE URBAN AREAS

	1974	1975	1976	1977	1978	1979	1980
TRANSMISSION SYSTEM COSTS	299.08	554.84	813.98	1576.01	2460.93	124.01	124.01
HOME COSTS	174.00	372.00	594.00	1188.00	1941.00	516.00	516.00
HEAD END COSTS	170.75	139.50	416.38	554.14	421.91	440.57	460.16
LOCAL ORIGINATION STUDIO	87.00	56.50	58.07	59.73	61.47	63.29	65.20
ADVERTISING AND MARKETING	100.00	90.00	90.00	90.00	90.00	90.00	90.00
PAY TV COSTS (INCL. HOME UNITS)	339.00	1478.25	2072.19	2535.03	2961.97	1404.22	1406.58
TOTAL SYSTEM COSTS	1169.84	2691.09	4044.63	6002.92	7937.28	2638.09	2661.96
CATV REVENUE	144.00	432.00	864.00	1728.00	3096.00	3096.00	3096.00
PAY TV REVENUE	0.00	249.60	1497.60	3244.80	5408.00	5408.00	5408.00
TOTAL REVENUE	144.00	681.60	2361.60	4972.80	8504.00	8504.00	8504.00
NET CASH FLOW	-1025.83	-2009.49	-1683.02	-1030.12	566.72	5865.91	5842.04
DISCOUNTED CASH FLOW	-1025.83	-1913.64	-1526.29	-889.63	466.09	4594.14	4357.20
PRESENT VALUE	4062.03						

Figure B-17 CATV Cash Flow Analysis

238

OCTOBER 25, 1973

CATV & PAY TV CASH FLOW ANALYSIS

(IN THOUSANDS OF DOLLARS)

(DISCOUNT RATE 10 PERCENT)

CATV SUBSCRIBERS 43000

PAY TV SUBSCRIBERS 26000

3 AREAS TOTALLING 50 SQ MI

AREAS INTERCONNECTED BY 2 MICROWAVE LINKS

DUAL CABLE - 2 WAY SYSTEM

DENSE URBAN AREAS

	1974	1975	1976	1977	1978	1979	1980
TRANSMISSION SYSTEM COSTS	299.08	554.84	813.98	1576.01	2460.93	124.01	124.01
HOME COSTS	174.00	372.00	594.00	1188.00	1941.00	516.00	516.00
HEAD END COSTS	170.75	139.50	416.38	554.14	421.91	440.57	460.16
LOCAL ORIGINATION STUDIO	87.00	56.50	58.07	59.73	61.47	63.29	65.20
ADVERTISING AND MARKETING	100.00	90.00	90.00	90.00	90.00	90.00	90.00
PAY TV COSTS (INCL. HOME UNITS)	339.00	1478.25	2072.19	2535.03	2961.97	1404.22	1406.58
TOTAL SYSTEM COSTS	1169.84	2691.09	4044.63	6002.92	7937.28	2638.09	2661.96
CATV REVENUE	144.00	432.00	864.00	1728.00	3096.00	3096.00	3096.00
PAY TV REVENUE	0.00	249.60	1497.60	3244.80	5408.00	5408.00	5408.00
TOTAL REVENUE	144.00	681.60	2361.60	4972.80	8504.00	8504.00	8504.00
NET CASH FLOW	-1025.83	-2009.49	-1683.02	-1030.12	566.72	5865.91	5842.04
DISCOUNTED CASH FLOW	-1025.83	-1826.53	-1390.65	-773.71	386.92	3640.44	3295.70
PRESENT VALUE	2306.25						

Figure B-18 CATV Cash Flow Analysis

OCTOBER 25, 1973

CATV & PAY TV CASH FLOW ANALYSIS

(IN THOUSANDS OF DOLLARS)

(DISCOUNT RATE 15 PERCENT)

CATV SUBSCRIBERS 43000

PAY TV SUBSCRIBERS 26000

3 AREAS TOTALLING 50 SQ MI

AREAS INTERCONNECTED BY 2 MICROWAVE LINKS

DUAL CABLE - 2 WAY SYSTEM

DENSE URBAN AREAS

	1974	1975	1976	1977	1978	1979	1980
TRANSMISSION SYSTEM COSTS	299.08	554.84	813.98	1576.01	2460.93	124.01	124.01
HOME COSTS	174.00	372.00	594.00	1188.00	1941.00	516.00	516.00
HEAD END COSTS	170.75	139.50	416.38	554.14	421.91	440.57	460.16
LOCAL ORIGINATION STUDIO	87.00	56.50	58.07	59.73	61.47	63.29	65.20
ADVERTISING AND MARKETING	100.00	90.00	90.00	90.00	90.00	90.00	90.00
PAY TV COSTS (INCL. HOME UNITS)	339.00	1478.25	2072.19	2535.03	2961.97	1404.22	1406.58
TOTAL SYSTEM COSTS	1169.84	2691.09	4044.63	6002.92	7937.28	2638.09	2661.96
CATV REVENUE	144.00	432.00	864.00	1728.00	3096.00	3096.00	3096.00
PAY TV REVENUE	0.00	249.60	1497.60	3244.80	5408.00	5408.00	5408.00
TOTAL REVENUE	144.00	681.60	2361.60	4972.80	8504.00	8504.00	8504.00
NET CASH FLOW	-1025.83	-2009.49	-1683.02	-1030.12	566.72	5865.91	5842.04
DISCOUNTED CASH FLOW	-1025.83	-1747.25	-1272.42	-677.17	323.93	2915.30	2524.54
PRESENT VALUE	1041.10						

Figure B-19 CATV Cash Flow Analysis

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